Supplemental Materials

Inspiring Australian secondary school students through the Science Bootcamp program

Prepared for:

Commonwealth Science & Industrial Research Organisation

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Author contributions

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Supplemental Material B

Sponsor Description

Commonwealth Scientific and Industrial Research Organisation's History, Goals, and Drive

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) was founded to promote scientific research for the benefit of the Australian people and economy. Today the leading scientific research agency of Australia, CSIRO, did not begin as a goliath of achievement. The Federal Parliament of Australia passed a bill that established the Advisory Council of Science and Industry (ACSI) in 1916, and the organization started its research with just £250 of investment capital from the Queensland and New South Wales governments. By 1927 the organization grew to 53 employees and had locations in all six Australian states. Several revisions of the act that created this organization caused ACSI to change its name, ultimately modifying it to the Commonwealth Scientific and Industrial Research Organisation in 1949. ("Our History", n.d).

As a government entity, CSIRO "[prioritizes their] research investments on the most important areas of national interest" ("Science", 2015). Initially, ACSI focused on general topics with regard to plants, animals, food preservation, and agricultural problems, such as invasive species. One of their first achievements was developing and publishing the most detailed soil map of Australia in 1944, as shown in Figure 1 ("Soil Map", 2011). During World War II, the organization shifted its focus to defense, developing radar and other systems for the Australian government ("Radar, 2011). When the war was over, research shifted to more physical science topics, such as resource extraction and atmospheric physics ("Our History", n.d). Ever since, CSIRO has continued to pursue new advancing scientific fields. They were responsible for the development of Australia's first electronic computer, the fifth in the world, in 1947 ("Our Top 10", 2015). CSIRO went on to design progressive eyeglass lenses that people around the world still use to this day ("Spectacle Lens Design", 2011) as well as create algorithms that contributed to the success of WiFi.

Self-described as Australia's innovation agency, CSIRO has grown to be Australian governments' most prominent scientific government agency, advancing Australia's place in the global economy through STEM research. They hold over 1,800 patents, which is more than any other organization in the nation ("Our Mission", n.d.). The majority of its funding (approximately 745,000 AUD in the 2014-2015 fiscal year) comes from the Australian government, with the remainder coming from a variety of private sector sources, including the private sector, as described in Table 1 (*Annual Report 2014-15*, 2015). In the 2014-2015 fiscal year, the organization served approximately 3,000 customers, 500 of which were major Australian companies (*Annual Report 2014-15*, 2015) with more than 5,000 employees at 55 centers in Australia and around the world ("Our Mission", n.d.).

Their current scientific research initiatives are divided into 8 business units as follows: Agriculture and Food, Health and Biosecurity, Data61, Energy, Land and Water, Manufacturing, Mineral Resources, as well as Oceans and Atmosphere ("Do Business with CSIRO", n.d.). These business units utilize multidisciplinary research teams to pursue a variety of applied research, in addition to developing innovative and high-tech products that draw on Australia's resource base and advance industrial productivity. In 2014, the focus of CSIRO was narrowed down to science, national facilities and collections, and CSIRO services ("Our History", n.d). These topics are focused on providing the Australian people and scientific industries with novel information and opportunities to improve various aspects of life. In addition to the principle business units, CSIRO invests in its own future through the creation and maintenance of several educational programs. These range from an educational cable television show and science bootcamps to a variety of teacher trainings (“Educational Programs”, n.d.).

Outreach programs have become increasingly important in the wake of declining interest in STEM fields among Australian secondary school students. In a study of math and science course selection in New South Wales, John Mack and Rachel Wilson determined that “there has been a substantial decline in the proportion of students undertaking at least one suitable mathematics course and one suitable science course in the [Higher School Certificate]” (“Trends”, 1). Furthermore, in 2012 less than 16% of college and graduate level programs completed were in STEM areas (Harper, 2014). As an organization dedicated to using innovation to further business growth, CSIRO is also concerned by how businesses are unable to find enough qualified candidates to fill STEM related positions (Randles, 2015).

The lack of student interest in the sciences is not only hurting technical and research organizations such as CSIRO, but is also working against their efforts to strengthen Australia’s economy. These coupled impacts of the student disinterest in STEM topics motivate CSIRO to find solutions to this issue, such as our project, that will improve their Science Bootcamp program effectiveness.

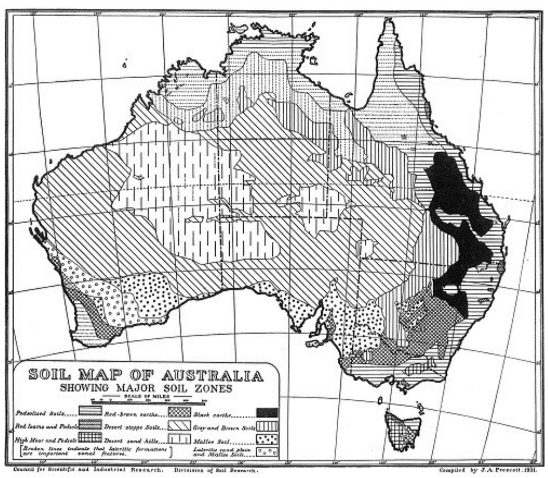

Figure 1. *A Soil Map of Australia [Source: 2d Edition, CSIRO Bulletin **52**, 1952] Retrieved from https://csiropedia.csiro.au/Soil-Map-of-Australia/*

REVENUE SOURCE	2010–11	2011–12	2012–13	2013–14	2014–15
Co-investment, consulting and services					
Australian private sector	65	74.2	70.1	78.5	69.4
Australian Governments	202.7	201.8	190.3	179.3	181.1
Rural Industry R&D corporations	37.7	35	38.4	50.2	38.1
Cooperative Research Centres	32.3	30	16.9	14.7	9.5
Overseas entities and international	74.5	77.5	84.3	84.7	81.4
Work in progress/deferred revenue	5.9	-7.6	25.1	-13	-6.1
Total co-investment, consulting and services	**418.1**	**410.9**	**425.1**	**394.4**	**373.4**
IP – royalty and licence revenues	29.2	278.5	37.5	29.1	60.8
Total research and services revenue	**447.3**	**689.4**	**462.6**	**423.5**	**434.2**
Other external revenue	47.9	61.3	44.1	43.2	44.6
Gain/(loss) on sale of assets	4.9	0.4	0	-	-
Other fair value gains and reversals	0.1	-	5.5	-	6.7
Total external revenue	**500.2**	**751.1**	**512.2**	**466.7**	**485.5**
Revenue from government	720.4	724.9	733.8	778.2	745.3
Total revenue	**1,220.6**	**1,476.0**	**1,246.0**	**1,244.9**	**1,230.8**
Less expenses	1,231.1	1,275.5	1,267.5	1,270.6	1,245.3
Operating result	**-10.5**	**200.5**	**-21.5**	**-25.7**	**-14.5**

Note, the 2014–15 total expenses of $1,245.3m includes CSIRO's share of the net operating deficit ($0.3m) of joint venture accounted for using the equity method.

Table 1. *CSIRO'S Financial Performance by Source of Revenue [Source: CSIRO Annual Report 2014-15, 2015] Retrieved from http://www.csiro.au/en/About/Our-impact/Reporting-our-impact/Annual-reports/14-15-annual-report*

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Soil Map of Australia - CSIROpedia. (2011). Retrieved August 28, 2016, from https://csiropedia.csiro.au/Soil-Map-of-Australia/

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Supplemental Material C

Data analysis coding keys

Below is the key for how the previous bootcamp participate surveys were entered into the logbook for analysis.

Key for "Rank Activities"	
If camp is Gel Electrophoresis	
1	Day 1 research presentation (Alicia)
2	Lab Tour: HRPPC
3	Lab tour: Herbarium
4	Video link up with the RV Investigator ship
5	Day 2 Research Presentation (Danny)
6	DNA to the Max Program
7	CSIRO quiz
8	DIY gel electrophoresis activityt across two days

Key for "Rank Activities"	
If camp is Gel Electrophoresis Brisbane Oct 15	
1	Day 1 research presentation (Jen)
2	Hands on DNA to the Max workshop
3	CSIRO quiz
4	Lab tour: Greenhouse (Raghu)
5	Lab tour: plankton research laboratory (Julian)
6	Day 2 research presentation (Christine)
7	DIY DNA gel electrophoresis
8	

Key for "Rank Activities"	
If camp is 3D printing Brisbane April 15	
1	Day 1:Research presentation. Unmanned Aerial Vehicles (
2	Lab tour: Remote Management
3	Lab tour: Robotics
4	Lab tour:Bat Monitoring
5	Day 2: Research Presentation(Anna Littleboy) Community
6	Hands-on Nanotechnology workshop
7	CSIRO video conference quiz Canberra April didn't work
8	3D design and printing activity and challenge

Key for "Rank Activities"	
If camp is 3D printing Canberra April 15	
1	Day 1 Research Pres:(Brian Lessard) Nat Insect Collection
2	Lab tour: High Res Plant Phenomics Centre
3	Lab tour: 3D titanium printing and cold spray
4	Lab tour: Metabolic Engineering of Plant oils
5	Day 2: Research Presentation (Colin Scott) Enviro & Indust
6	Hands-on Nanotechnology workshop
7	CSIRO video conference quiz Canberra April didn't work

Key for "Why attend?"	
1	Interested in a particular topic
2	Looked fun
3	For the lab tours
4	For the activities
5	To meet scientists
6	Northing else to do during the holidays
7	My parents made me.

Key for "Rank Activities"	
If camp is Phone Speaker Canberra Sept 16	
1	Day 1 research Presentation (Mike, 3D scanner)
2	Day 2 research presentation (Mick)
3	Hands-on Forensic Science Workshop
4	Audio Amplifier activity across the two days
5	
6	
7	
8	

Key for "Rank Activities"	
If camp is Phone Speaker Sydney Jan 16	
1	Day 1 research presentation (Lawrence)
2	Lab tour: mineral resources
3	Lab tour: Biocampatibility
4	Video link up with the RV Investigator vessel
5	Day 2 research presentation (Meg)
6	Hands-On Forensic Science workshop
7	CSIRO quiz
8	Audio Amplifier activity across the two days

Key for "Rank Activities"	
If camp is Phone Speaker Melbourne Jan 16	
1	Day 1 research presentation (Kate)
2	Lab Tour: Anechoic Chamber
3	Lab Tour: Energy Labs
4	Video link up with the RV Investigator Ship
5	Day 2 research presentation (Adam)
6	Hands-on forensic science workshop
7	CSIRO quiz

Key for "Why attend?": Rank Reasons on a scale from 0-5	
1	Interested in a particular topic
2	Looked fun
3	For the lab tours
4	For the activities
5	To meet scientists
6	Northing else to do during the holidays
7	My parents made me.
8	Other

Key for "Why attend?" Hobart June-July 2015	
1	Interested in the particular topic
2	Looked fun
3	For the lab tours
4	For the 3D printing
5	To meet scientists
6	Northing else to do during the holidays
7	My parents made me.
8	Other

Key for "Rank Activities"	
If camp is Sydney June/July 2015	
1	Electrophoresis and DNA extraction how-to
2	Research Presentation: Chris Hammang, biomedical an
3	DIY DNA Extraction
4	DIY Electrophoesis
5	Day 2: Lab tour- Mycology (mould) lab, Nai Tran-Dinh
6	Lab tour- Anaerobic lab, David Midgeley
7	Lab tour- Isotope geochemistry lab, Jenny Van Holst
8	Research Presentation: Yalchin Oytam, data analysis
9	Genetic Phenotyping activity (corn)

Key for "Rank Activities"	
If camp is Melbourne June/July 2015	
1	Day 1: research presentation (Melanie)
2	Lab tour: Bioreactors
3	Lab tour: Mesenchymal Stem Cells and Materials
4	Lab tour: Medicinal Chemistry
5	Day 2: research presenttaion (Dave)
6	Hands-on DNA to the Max workshop

Supplemental Material D

Full student survey data analysis results

Below are the results from using SPSS to analyze the data we collected to answer the research questions. The question that the data answers is at the beginning of each data output. A full explanation of the results is in the text.

Did students find any of the activities particularly enjoyable or boring?

```
SAVE OUTFILE='C:\Users\Nick\Documents\SPSS Student Logbook.sav'   /COMPRESSED.
GET DATA /TYPE=XLSX
  /FILE='C:\Users\Nick\Desktop\Parent Logbook 4 SPSS.xlsx'
  /SHEET=name 'Sheet1'
  /CELLRANGE=full
  /READNAMES=on
  /ASSUMEDSTRWIDTH=32767.
EXECUTE.
DATASET NAME DataSet2 WINDOW=FRONT.
DATASET ACTIVATE DataSet2.
DATASET CLOSE DataSet1.

SAVE OUTFILE='C:\Users\Nick\Desktop\SPSS Parent Logbook.sav'   /COMPRESSED.

GET
  FILE='C:\Users\Nick\Documents\SPSS Student Logbook.sav'.
DATASET NAME DataSet1 WINDOW=FRONT.
ONEWAY Bootcamp BY ScaledRatingofMainActivity   /MISSING
ANALYSIS.
```

Oneway

[DataSet1] C:\Users\Nick\Documents\SPSS Student Logbook.sav

ANOVA

MainActivity

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.977	7	.568	.563	.786
Within Groups	341.367	338	1.010		
Total	345.344	345			

```
ONEWAY Bootcamp BY ScaledRatingofMainActivity
  /MISSING ANALYSIS
  /POSTHOC=GT2 ALPHA(0.05).
```

Oneway

Warnings

Post hoc tests are not performed for MainActivity because at least one group has fewer than two cases.

ANOVA

MainActivity

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.977	7	.568	.563	.786
Within Groups	341.367	338	1.010		
Total	345.344	345			

```
ONEWAY ScaledRatingofMainActivity BY Bootcamp
  /MISSING ANALYSIS
  /POSTHOC=GT2 ALPHA(0.05).
```

Oneway

ANOVA

Scaled Rating of Main Activity

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	15.108	3	5.036	3.063	.028
Within Groups	562.236	342	1.644		
Total	577.344	345			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Scaled Rating of Main Activity

Hochberg

(I) MainActivity	(J) MainActivity	Mean Difference (I-J)	Std. Error	Sig.
Phone Speaker	Gel Electrophoresis	.4117	.1958	.198
	3D Printing	.2572	.1929	.701
	Magnetic Slime and Slick Activity	-.1574	.2266	.982
Gel Electrophoresis	Phone Speaker	-.4117	.1958	.198
	3D Printing	-.1545	.1746	.941
	Magnetic Slime and Slick Activity	-.5692*	.2113	.044

3D Printing	Phone Speaker	-.2572	.1929	.701
	Gel Electrophoresis	.1545	.1746	.941
	Magnetic Slime and Slick Activity	-.4146	.2086	.253
Magnetic Slime and Slick Activity	Phone Speaker	.1574	.2266	.982
	Gel Electrophoresis	.5692*	.2113	.044
	3D Printing	.4146	.2086	.253

Multiple Comparisons

Dependent Variable: Scaled Rating of Main Activity

Hochberg

		95% Confidence Interval	
(I) MainActivity	(J) MainActivity	Lower Bound	Upper Bound
Phone Speaker	Gel Electrophoresis	-.106	.930
	3D Printing	-.253	.767
	Magnetic Slime and Slick Activity	-.757	.442
Gel Electrophoresis	Phone Speaker	-.930	.106
	3D Printing	-.616	.307
	Magnetic Slime and Slick Activity	-1.128	-.010
3D Printing	Phone Speaker	-.767	.253
	Gel Electrophoresis	-.307	.616
	Magnetic Slime and Slick Activity	-.967	.137
Magnetic Slime and Slick Activity	Phone Speaker	-.442	.757
	Gel Electrophoresis	.010 -	1.128
	3D Printing	.137	.967

*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets

Scaled Rating of Main Activity

Hochberg[a,b]

		Subset for alpha = 0.05	
MainActivity	N	1	2

Gel Electrophoresis	104	4.712	
3D Printing	112	4.866	4.866
Phone Speaker	73	5.123	5.123
Magnetic Slime and Slick Activity Sig.	57		5.281
		.229	.222

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 80.343.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Did either gender enjoy any of the main activities more than the other?

```
SORT CASES  BY Bootcamp. SPLIT FILE
SEPARATE BY Bootcamp.
T-TEST GROUPS=Gender(0 1)
  /MISSING=ANALYSIS
  /VARIABLES=ScaledRatingofMainActivity   /CRITERIA=CI(.95).
```

T-Test

MainActivity = Phone Speaker

Group Statistics[a]

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Scaled Rating of Main Activity	M	26	5.115	.9931	.1948
	F	10	5.500	1.2693	.4014

a. MainActivity = Phone Speaker

Independent Samples Test[a]

		Levene's Test for Equality of Variances		t-test for Equality of
		F	Sig.	t
Scaled Rating of Main Activity	Equal variances assumed	.004	.948	-.963
	Equal variances not assumed			-.862

Independent Samples Test[a]

Independent Samples Test[a]

		t-test for Equality of Means		
		df	Sig. (2-tailed)	Mean Difference
Scaled Rating of Main Activity	Equal variances assumed	34	.342	-.3846
	Equal variances not assumed	13.468	.404	-.3846

		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
Scaled Rating of Main Activity	Equal variances assumed	.3993	-1.1961	.4269
	Equal variances not assumed	.4461	-1.3450	.5758

a. MainActivity = Phone Speaker

MainActivity = Gel Electrophoresis

Group Statistics[a]

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Scaled Rating of Main Activity	M	7	5.571	.7319	.2766
	F	12	5.625	.6784	.1958

	t-test for Equality of Means		
	df	Sig. (2-tailed)	Mean Difference

Independent Samples Test[a]

Scaled Rating of Main Activity	Equal variances assumed	17	.874	-.0536
	Equal variances not assumed	11.892	.877	-.0536

a. MainActivity = Gel Electrophoresis

Independent Samples Test[a]

		Levene's Test for Equality of Variances		t-test for Equality of
		F	Sig.	t
Scaled Rating of Main Activity	Equal variances assumed	.100	.755	-.161 - .158
	Equal variances not assumed			

.

Independent Samples Test[a]

		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
Scaled Rating of Main Activity	Equal variances assumed	.3319	-.7537	.6466
	Equal variances not assumed	.3389	-.7928	.6857

a. MainActivity = Gel Electrophoresis

Independent Samples Test[a]

MainActivity = 3D Printing

Group Statistics[a]

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Scaled Rating of Main Activity	M	40	4.888	1.4344	.2268
	F	19	5.684	1.0699	.2455

	t-test for Equality of Means		
	df	Sig. (2-tailed)	Mean Difference

Independent Samples Test[a]

Scaled Rating of Main Activity	Equal variances assumed	57	.036	-.7967
	Equal variances not assumed	46.285	.021	-.7967

a. MainActivity = 3D Printing

Independent Samples Test[a]

		Levene's Test for Equality of Variances		t-test for Equality of
		F	Sig.	t
Scaled Rating of Main Activity	Equal variances assumed	9.132	.004	-2.150
	Equal variances not assumed			-2.384

Independent Samples Test[a]

		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
Scaled Rating of Main Activity	Equal variances assumed	.3706	-1.5388	-.0546
	Equal variances not assumed	.3342	-1.4693	-.1241

a. MainActivity = 3D Printing

Independent Samples Test[a]

MainActivity = Magnetic Slime and Slick Activity

Group Statistics[a]

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Scaled Rating of Main Activity	M	4	5.250	.5000	.2500
	F	6	5.167	.7528	.3073

	t-test for Equality of Means		
	df	Sig. (2-tailed)	Mean Difference

Independent Samples Test[a]

Scaled Rating of Main Activity	Equal variances assumed	8	.852	.0833
	Equal variances not assumed	7.982	.839	.0833

a. MainActivity = Magnetic Slime and Slick Activity

Independent Samples Test[a]

		Levene's Test for Equality of Variances		t-test for Equality of
		F	Sig.	t
Scaled Rating of Main Activity	Equal variances assumed	.535	.485	.193 .210
	Equal variances not assumed			

Independent Samples Test[a]

		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
Scaled Rating of Main Activity	Equal variances assumed	.4320	-.9129	1.0795
	Equal variances not assumed	.3962	-.8306	.9973

a. MainActivity = Magnetic Slime and Slick Activity

Was the type of main activity correlated with students' reported likelihood of returning?

```
SPLIT FILE OFF.
ONEWAY LikelytoReturn BY Bootcamp
  /MISSING ANALYSIS
  /POSTHOC=GT2 ALPHA(0.05).
```

Oneway

ANOVA

Likely to Return

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	41899.506	3	13966.502	1.229	.299
Within Groups	3865051.398	340	11367.798		
Total	3906950.904	343			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Likely to Return

Hochberg

(I) MainActivity	(J) MainActivity	Mean Difference (I-J)	Std. Error	Sig.
Phone Speaker	Gel Electrophoresis	-10.320	16.312	.989
	3D Printing	-9.279	16.067	.993
	Magnetic Slime and Slick Activity	-35.048	18.846	.325
Gel Electrophoresis	Phone Speaker	10.320	16.312	.989
	3D Printing	1.041	14.587	1.000
	Magnetic Slime and Slick Activity	-24.728	17.601	.649
3D Printing	Phone Speaker	9.279	16.067	.993
	Gel Electrophoresis	-1.041	14.587	1.000
	Magnetic Slime and Slick Activity	-25.769	17.374	.591
Magnetic Slime and Slick Activity	Phone Speaker	35.048	18.846	.325
	Gel Electrophoresis	24.728	17.601	.649
	3D Printing	25.769	17.374	.591

Multiple Comparisons

Dependent Variable: Likely to Return Hochberg

(I) MainActivity	(J) MainActivity	95% Confidence Interval Lower Bound	Upper Bound
Phone Speaker	Gel Electrophoresis	-53.48	32.84
	3D Printing	-51.79	33.23
	Magnetic Slime and Slick Activity	-84.91	14.81
Gel Electrophoresis	Phone Speaker	-32.84	53.48
	3D Printing	-37.55	39.63
	Magnetic Slime and Slick Activity	-71.30	21.84
3D Printing	Phone Speaker	-33.23	51.79
	Gel Electrophoresis	-39.63	37.55
	Magnetic Slime and Slick Activity	-71.74	20.20
Magnetic Slime and Slick Activity	Phone Speaker	-14.81	84.91
	Gel Electrophoresis	-21.84	71.30
	3D Printing	-20.20	71.74

Homogeneous Subsets

Likely to Return

Hochberg[a,b]

MainActivity	N	Subset for alpha = 0.05 1
Phone Speaker	73	4.67
3D Printing	111	13.95
Gel Electrophoresis	103	14.99
Magnetic Slime and Slick Activity	57	39.72
Sig.		.208

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 80.064.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Did any of the main activities have a high or lower likelihood of the parent rebooking?

```
DATASET CLOSE DataSet1.
ONEWAY IwouldbookintoaCSIRObootcampagain BY forwhatactivity
  /MISSING ANALYSIS
  /POSTHOC=GT2 ALPHA(0.05).
```

Oneway

ANOVA

Likelihood of Rebooking

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.267	2	.634	1.012	.368
Within Groups	51.942	83	.626		
Total	53.209	85			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Likelihood of Rebooking

Hochberg

					95% ...
(I) Activity	(J) Activity	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound
Gel Electrophoresis	Phone Speaker	-.376	.265	.402	-1.02
	3D Printing	-.269	.261	.662	-.91
Phone Speaker	Gel Electrophoresis	.376	.265	.402	-.27
	3D Printing	.107	.184	.915	-.34
3D Printing	Gel Electrophoresis	.269	.261	.662	-.37
	Phone Speaker	-.107	.184	.915	-.56

Multiple Comparisons

Dependent Variable: Likelihood of Rebooking

Hochberg

(I) Activity	(J) Activity	95% Confidence Upper Bound
Gel Electrophoresis	Phone Speaker	.27
	3D Printing	.37
Phone Speaker	Gel Electrophoresis	1.02
	3D Printing	.56
3D Printing	Gel Electrophoresis	.91
	Phone Speaker	.34

Homogeneous Subsets

Likelihood of Rebooking

Hochberg[a,b]

Activity	N	Subset for alpha = 0.05 1
Gel Electrophoresis	12	4.17
3D Printing	39	4.44
Phone Speaker	35	4.54
Sig.		.317

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 21.811.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Did younger or older students like any main activity more or less than another age group?

```
SORT CASES  BY Bootcamp. SPLIT FILE
SEPARATE BY Bootcamp.
T-TEST GROUPS=Gender(0 1)
  /MISSING=ANALYSIS
  /VARIABLES=ScaledRatingofMainActivity   /CRITERIA=CI(.95).
```

T-Test

MainActivity = Phone Speaker

Group Statistics[a]

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Scaled Rating of Main Activity	M	26	5.115	.9931	.1948
	F	10	5.500	1.2693	.4014

a. MainActivity = Phone Speaker

Independent Samples Test[a]

		Levene's Test for Equality of Variances		t-test for Equality of
		F	Sig.	t
Scaled Rating of Main Activity	Equal variances assumed	.004	.948	-.963 -
	Equal variances not assumed			.862

.

Independent Samples Test[a]

Independent Samples Test[a]

		t-test for Equality of Means		
		df	Sig. (2-tailed)	Mean Difference
Scaled Rating of Main Activity	Equal variances assumed	34	.342	-.3846
	Equal variances not assumed	13.468	.404	-.3846

		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
Scaled Rating of Main Activity	Equal variances assumed	.3993	-1.1961	.4269
	Equal variances not assumed	.4461	-1.3450	.5758

a. MainActivity = Phone Speaker

MainActivity = Gel Electrophoresis

Group Statistics[a]

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Scaled Rating of Main Activity	M	7	5.571	.7319	.2766
	F	12	5.625	.6784	.1958

a. MainActivity = Gel Electrophoresis

Independent Samples Test[a]

Independent Samples Test[a]

		Levene's Test for Equality of Variances		t-test for Equality of
		F	Sig.	t
Scaled Rating of Main Activity	Equal variances assumed	.100	.755	-.161
	Equal variances not assumed			-.158

.

Independent Samples Test[a]

		t-test for Equality of Means		
		df	Sig. (2-tailed)	Mean Difference
Scaled Rating of Main Activity	Equal variances assumed	17	.874	-.0536
	Equal variances not assumed	11.892	.877	-.0536

		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
Scaled Rating of Main Activity	Equal variances assumed	.3319	-.7537	.6466
	Equal variances not assumed	.3389	-.7928	.6857

a. MainActivity = Gel Electrophoresis

Independent Samples Test[a]

MainActivity = 3D Printing

Group Statistics[a]

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Scaled Rating of Main Activity	M	40	4.888	1.4344	.2268
	F	19	5.684	1.0699	.2455

a. MainActivity = 3D Printing

Independent Samples Test[a]

		Levene's Test for Equality of Variances		t-test for Equality of
		F	Sig.	t
Scaled Rating of Main Activity	Equal variances assumed	9.132	.004	-2.150
	Equal variances not assumed			-2.384

Independent Samples Test[a]

		t-test for Equality of Means		
		df	Sig. (2-tailed)	Mean Difference
Scaled Rating of Main Activity	Equal variances assumed	57	.036	-.7967
	Equal variances not assumed	46.285	.021	-.7967

Independent Samples Test[a]

		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
Scaled Rating of Main Activity	Equal variances assumed	.3706	-1.5388	-.0546
	Equal variances not assumed	.3342	-1.4693	-.1241

a. MainActivity = 3D Printing

MainActivity = Magnetic Slime and Slick Activity

Group Statistics[a]

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Scaled Rating of Main Activity	M	4	5.250	.5000	.2500
	F	6	5.167	.7528	.3073

a. MainActivity = Magnetic Slime and Slick Activity

Independent Samples Test[a]

		Levene's Test for Equality of Variances		t-test for Equality of
		F	Sig.	t
Scaled Rating of Main Activity	Equal variances assumed	.535	.485	
	Equal variances not assumed			.193 .210

Independent Samples Test[a]

Independent Samples Test[a]

		t-test for Equality of Means		
		df	Sig. (2-tailed)	Mean Difference
Scaled Rating of Main Activity	Equal variances assumed	8	.852	.0833
	Equal variances not assumed	7.982	.839	.0833

		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
Scaled Rating of Main Activity	Equal variances assumed	.4320	-.9129	1.0795
	Equal variances not assumed	.3962	-.8306	.9973

a. MainActivity = Magnetic Slime and Slick Activity

```
SORT CASES  BY Bootcamp. SPLIT FILE
SEPARATE BY Bootcamp.
ONEWAY ScaledRatingofMainActivity BY Age
  /MISSING ANALYSIS
  /POSTHOC=GT2 ALPHA(0.05).
```

Oneway

Warnings

No valid cases were found in split file MainActivity = 3D Printing. No statistics are computed for this split file.
Post hoc tests are not performed for Scaled Rating of Main Activity in split file MainActivity = Magnetic Slime and Slick Activity because at least one group has fewer than two cases.

MainActivity = Phone Speaker

ANOVA[a]

Scaled Rating of Main Activity

Independent Samples Test[a]

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	11.288	4	2.822	2.881	.029
Within Groups	66.602	68	.979		
Total	77.890	72			

a. MainActivity = Phone Speaker

Post Hoc Tests

Multiple Comparisons[a]

Dependent Variable: Scaled Rating of Main Activity

Hochberg

(I) Age	(J) Age	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
12	13	-.3235	.3323	.980	-1.283	.636
	14	-.2778	.3688	.997	-1.343	.787
	15	1.2000	.5268	.225	-.321 -	2.721
	16	.2500	.5714	1.000	1.400	1.900
13	12	.3235	.3323	.980	-.636	1.283
	14	.0458	.2885	1.000	-.787	.879
	15	1.5235*	.4740	.020	.154 -	2.893
	16	.5735	.5231	.955	.937	2.084
14	12	.2778	.3688	.997	-.787	1.343
	13	-.0458	.2885	1.000	-.879	.787
	15	1.4778*	.5003	.042	.033	2.923
	16	.5278	.5471	.981	-1.052	2.108
15	12	-1.2000	.5268	.225	-2.721 -	.321 -
	13	-1.5235*	.4740	.020	2.893	.154
	14	-1.4778*	.5003	.042	-2.923 -	-.033
	16	-.9500	.6639	.805	2.867	.967
16	12	-.2500	.5714	1.000	-1.900	1.400
	13	-.5735	.5231	.955	-2.084	.937
	14	-.5278	.5471	.981	-2.108	1.052
	15	.9500	.6639	.805	-.967	2.867

*. The mean difference is significant at the 0.05 level.

a. MainActivity = Phone Speaker

Homogeneous Subsets

Scaled Rating of Main Activity[a]

b,c[b,c]

Hochberg

Age	N	Subset for alpha = 0.05	
		1	2
15	5	3.800	
16	4	4.750	4.750
12	12	5.000	5.000
14	18		5.278
13	34		5.324
Sig.		.157	.935

Means for groups in homogeneous subsets are displayed.

a. MainActivity = Phone Speaker

b. Uses Harmonic Mean Sample Size = 8.087.

c. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

MainActivity = Gel Electrophoresis

ANOVA[a]

Scaled Rating of Main Activity

	Sum of Squares	df	Mean Square	F	Sig.

Between Groups	6.030	4	1.508	2.239	.089
Within Groups	19.529	29	.673		
Total	25.559	33			

a. MainActivity = Gel Electrophoresis

Post Hoc Tests

Multiple Comparisons[a]

Dependent Variable: Scaled Rating of Main Activity

Hochberg

(I) Age	(J) Age	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
12	13	.4286	.6203	.998	-1.440	2.297
	14	1.3000	.6356	.375	-.615 -	3.215
	15	1.0000	.6866	.784	1.068	3.068
	16	1.0000	.7491	.855	-1.257	3.257
13	12	-.4286	.6203	.998	-2.297	1.440
	14	.8714	.3398	.139	-.152	1.895
	15	.5714	.4275	.854	-.716	1.859
	16	.5714	.5221	.951	-1.001	2.144
14	12	-1.3000	.6356	.375	-3.215	.615
	13	-.8714	.3398	.139	-1.895	.152
	15	-.3000	.4495	.999	-1.654	1.054
	16	-.3000	.5402	1.000	-1.927	1.327
15	12	-1.0000	.6866	.784	-3.068	1.068
	13	-.5714	.4275	.854	-1.859	.716
	14	.3000	.4495	.999	-1.054	1.654
	16	.0000	.5993	1.000	-1.805	1.805

16	12	-1.0000	.7491	.855	-3.257	1.257
	13	-.5714	.5221	.951	-2.144	1.001
	14	.3000	.5402	1.000	-1.327	1.927
	15	.0000	.5993	1.000	-1.805	1.805

a. MainActivity = Gel Electrophoresis

Homogeneous Subsets

Scaled Rating of Main Activity[a]

b,c[b,c]

Hochberg

Age	N	Subset for alpha = 0.05
		1
14	10	4.700
15	5	5.000
16	3	5.000
13	14	5.571
12	2	6.000
Sig.		.246

Means for groups in homogeneous subsets are displayed.

a. MainActivity = Gel Electrophoresis

b. Uses Harmonic Mean Sample Size = 4.150.

c. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

MainActivity = Magnetic Slime and Slick Activity

ANOVA[a]

Scaled Rating of Main Activity

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.431	5	.486	.883	.500
Within Groups	25.871	47	.550		
Total	28.302	52			

a. MainActivity = Magnetic Slime and Slick Activity

Did location affect their enjoyment of the main activity?

```
SORT CASES  BY Location. SPLIT FILE
SEPARATE BY Location.
ONEWAY ScaledRatingofMainActivity BY Bootcamp
  /MISSING ANALYSIS
  /POSTHOC=GT2 ALPHA(0.05).
```

Oneway

Warnings

No valid cases were found in split file Location = . No statistics are computed for this split file.
There are fewer than two groups for dependent variable Scaled Rating of Main Activity in split file Location = Adelaide. No statistics are computed.
There are fewer than two groups for dependent variable Scaled Rating of Main Activity in split file Location = Tasmania. No statistics are computed.

Location = Brisbane

ANOVA[a]

Scaled Rating of Main Activity

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.319	2	1.659	1.869	.165
Within Groups	46.181	52	.888		
Total	49.500	54			

a. Location = Brisbane

Post Hoc Tests

Multiple Comparisons[a]

Dependent Variable: Scaled Rating of Main Activity

Hochberg

					95% ...
(I) MainActivity	(J) MainActivity	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound
Phone Speaker	Gel Electrophoresis	-.7481	.4167	.215	-1.775
	3D Printing	-.7291	.3969	.198	-1.707
Gel Electrophoresis	Phone Speaker	.7481	.4167	.215	-.279
	3D Printing	.0191	.2781	1.000	-.666

3D Printing	Phone Speaker Gel Electrophoresis	.7291 -.0191	.3969 .2781	.198 1.000	-.249 -.704

Multiple Comparisons[a]

Dependent Variable: Scaled Rating of Main Activity

Hochberg

(I) MainActivity	(J) MainActivity	95% Confidence Upper Bound
Phone Speaker	Gel Electrophoresis	.279
	3D Printing	.249
Gel Electrophoresis	Phone Speaker	1.775
	3D Printing	.704
3D Printing	Phone Speaker Gel Electrophoresis	1.707 .666

a. Location = Brisbane

Homogeneous Subsets

Scaled Rating of Main Activity[a]

b,c[b,c]

Hochberg

MainActivity	N	Subset for alpha = 0.05: 1
Phone Speaker	7	4.857
3D Printing	29	5.586
Gel Electrophoresis	19	5.605
Sig.		.135

Means for groups in homogeneous subsets are displayed.

a. Location = Brisbane

b. Uses Harmonic Mean Sample Size = 13.045.

c. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Location = Canberra

ANOVA[a]

Scaled Rating of Main Activity

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.638	2	.819	.926	.402
Within Groups	49.490	56	.884		
Total	51.127	58			

a. Location = Canberra

Post Hoc Tests

Multiple Comparisons[a]

Dependent Variable: Scaled Rating of Main Activity

Hochberg

(I) MainActivity	(J) MainActivity	Mean Difference (I-J)	Std. Error	Sig.	95% ... Lower Bound
Phone Speaker	Gel Electrophoresis	-.4167	.3423	.537	-1.258
	3D Printing	-.4375	.3423	.496	-1.279
Gel Electrophoresis	Phone Speaker	.4167	.3423	.537	-.425
	3D Printing	-.0208	.2714	1.000	-.688
3D Printing	Phone Speaker Gel	.4375	.3423	.496	-.404
	Electrophoresis	.0208	.2714	1.000	-.646

Multiple Comparisons[a]

Dependent Variable: Scaled Rating of Main Activity

Hochberg

(I) MainActivity	(J) MainActivity	95% Confidence Upper Bound
Phone Speaker	Gel Electrophoresis	.425
	3D Printing	.404
Gel Electrophoresis	Phone Speaker	1.258
	3D Printing	.646
3D Printing	Phone Speaker Gel	1.279
	Electrophoresis	.688

a. Location = Canberra

Homogeneous Subsets

Scaled Rating of Main Activity[a]

b,c[b,c]

Hochberg

MainActivity	N	Subset for alpha = 0.05
		1
Phone Speaker	11	5.000
Gel Electrophoresis	24	5.417
3D Printing Sig.	24	5.438
		.440

Means for groups in homogeneous subsets are displayed.

a. Location = Canberra

b. Uses Harmonic Mean Sample Size = 17.217.

c. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Location = Melbourne

ANOVA[a]

Scaled Rating of Main Activity

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.224	3	1.075	1.162	.328
Within Groups	86.901	94	.924		
Total	90.125	97			

a. Location = Melbourne

Post Hoc Tests

Multiple Comparisons[a]

Dependent Variable: Scaled Rating of Main Activity

Hochberg

(I) MainActivity	(J) MainActivity	Mean Difference (I-J)	Std. Error	Sig.
Phone Speaker	Gel Electrophoresis	-.3889	.2669	.612
	3D Printing	.0588	.3023	1.000
	Magnetic Slime and Slick Activity	-.2759	.2624	.874
Gel Electrophoresis	Phone Speaker	.3889	.2669	.612
	3D Printing	.4477	.2977	.577
	Magnetic Slime and Slick Activity	.1130	.2571	.998
3D Printing	Phone Speaker	-.0588	.3023	1.000
	Gel Electrophoresis	-.4477	.2977	.577
	Magnetic Slime and Slick Activity	-.3347	.2937	.827
Magnetic Slime and Slick Activity	Phone Speaker	.2759 -	.2624	.874
	Gel Electrophoresis	.1130	.2571	.998
	3D Printing	.3347	.2937	.827

Multiple Comparisons[a]

Dependent Variable: Scaled Rating of Main Activity

Hochberg

(I) MainActivity	(J) MainActivity	95% Confidence Interval	
		Lower Bound	Upper Bound
Phone Speaker	Gel Electrophoresis	-1.105	.328
	3D Printing	-.753	.870
	Magnetic Slime and Slick Activity	-.980	.429
Gel Electrophoresis	Phone Speaker	-.328	1.105
	3D Printing	-.352	1.247
	Magnetic Slime and Slick Activity	-.577	.803
3D Printing	Phone Speaker	-.870	.753
	Gel Electrophoresis	-1.247	.352
	Magnetic Slime and Slick Activity	-1.123	.454

Magnetic Slime and Slick Activity	Phone Speaker	-.429	.980
	Gel Electrophoresis	-.803	.577
	3D Printing	-.454	1.123

a. Location = Melbourne

Homogeneous Subsets

Scaled Rating of Main Activity[a]

b,c[b,c]

Hochberg

MainActivity	N	Subset for alpha = 0.05
		1
3D Printing	17	4.941
Phone Speaker	25	5.000
Magnetic Slime and Slick Activity	29	5.276
Gel Electrophoresis Sig.	27	5.389
		.510

Means for groups in homogeneous subsets are displayed.

a. Location = Melbourne

b. Uses Harmonic Mean Sample Size = 23.482.

c. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Location = Sydney

ANOVA[a]

Scaled Rating of Main Activity

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	155.938	3	51.979	46.249	.000
Within Groups	121.381	108	1.124		
Total	277.319	111			

a. Location = Sydney

Post Hoc Tests

Multiple Comparisons[a]

Dependent Variable: Scaled Rating of Main Activity
Hochberg

(I) MainActivity	(J) MainActivity	Mean Difference (I-J)	Std. Error	Sig.
Phone Speaker	Gel Electrophoresis	2.7917*	.2903	.000
	3D Printing	1.9167*	.2737	.000
	Magnetic Slime and Slick Activity	.0476	.2786	1.000
Gel Electrophoresis	Phone Speaker	-2.7917*	.2903	.000
	3D Printing	-.8750*	.2903	.019
	Magnetic Slime and Slick Activity	-2.7440*	.2949	.000
3D Printing	Phone Speaker	-1.9167*	.2737	.000
	Gel Electrophoresis	.8750* -1.8690*	.2903	.019
	Magnetic Slime and Slick Activity		.2786	.000
Magnetic Slime and Slick Activity	Phone Speaker	-.0476	.2786	1.000
	Gel Electrophoresis	2.7440*	.2949	.000
	3D Printing	1.8690*	.2786	.000

Multiple Comparisons[a]

Dependent Variable: Scaled Rating of Main Activity
Hochberg

		95% Confidence Interval	
(I) MainActivity	(J) MainActivity	Lower Bound	Upper Bound
Phone Speaker	Gel Electrophoresis	2.014	3.569
	3D Printing	1.184	2.650
	Magnetic Slime and Slick Activity	-.698	.794
Gel Electrophoresis	Phone Speaker	-3.569	-2.014
	3D Printing	-1.652	-.098
	Magnetic Slime and Slick Activity	-3.534	-1.954

3D Printing	Phone Speaker	-2.650	-1.184
	Gel Electrophoresis	.098	1.652
	Magnetic Slime and Slick Activity	-2.615	-1.123
Magnetic Slime and Slick Activity	Phone Speaker	-.794	.698
	Gel Electrophoresis	1.954	3.534
	3D Printing	1.123	2.615

*. The mean difference is significant at the 0.05 level.

a. Location = Sydney

Homogeneous Subsets

Scaled Rating of Main Activity[a]

b,c[b,c]

Hochberg

MainActivity	N	Subset for alpha = 0.05		
		1	2	3
Gel Electrophoresis	24	2.542		
3D Printing	30			
Magnetic Slime and Slick Activity	28			5.286
Phone Speaker Sig.	30	1.000	3.417 1.000	5.333 1.000

Means for groups in homogeneous subsets are displayed.

a. Location = Sydney

b. Uses Harmonic Mean Sample Size = 27.769.

c. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Did gender affect the likelihood of the student returning?

```
T-TEST GROUPS=Gender(0 1)
  /MISSING=ANALYSIS
  /VARIABLES=LikelytoReturn   /CRITERIA=CI(.95).
```

T-Test

MainActivity = Phone Speaker

Group Statistics[a]

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Likely to Return	M	26	4.42	1.391	.273
	F	10	4.80	.789	.249

a. MainActivity = Phone Speaker

Independent Samples Test[a]

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
Likely to Return	Equal variances assumed	2.325	.137	-.804	34
	Equal variances not assumed			-1.020	28.643

Independent Samples Test[a]

		t-test for Equality of Means		
		Sig. (2-tailed)	Mean Difference	Std. Error Difference
Likely to Return	Equal variances assumed	.427	-.377	.469
	Equal variances not assumed	.316	-.377	.370

	t-test for Equality of Means

Independent Samples Test[a]

		95% Confidence Interval of the Difference	
		Lower	Upper
Likely to Return	Equal variances assumed	-1.329	.576
	Equal variances not assumed	-1.133	.379

a. MainActivity = Phone Speaker

MainActivity = Gel Electrophoresis

Group Statistics[a]

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Likely to Return	M	7	5.51	1.096	.414
	F	12	6.00	.739	.213

	t-test for Equality of Means		
	Sig. (2-tailed)	Mean Difference	Std. Error Difference

Independent Samples Test[a]

Likely to Return	Equal variances assumed	.263	-.486	.419
	Equal variances not assumed	.324	-.486	.466

a. MainActivity = Gel Electrophoresis

Independent Samples Test[a]

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
Likely to Return	Equal variances assumed	1.660	.215	-1.159	17
	Equal variances not assumed			-1.042	9.245

Independent Samples Test[a]

		t-test for Equality of Means	
		95% Confidence Interval of the Difference	
		Lower	Upper
Likely to Return	Equal variances assumed	-1.370	.399
	Equal variances not assumed	-1.535	.564

a. MainActivity = Gel Electrophoresis

MainActivity = 3D Printing

Group Statistics[a]

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Likely to Return	M	39	4.63	1.716	.275
	F	19	5.26	1.327	.304

Independent Samples Test[a]

	t-test for Equality of Means		
	Sig. (2-tailed)	Mean Difference	Std. Error Difference

Independent Samples Test[a]

Likely to Return	Equal variances assumed	.162	-.635	.448
	Equal variances not assumed	.128	-.635	.410

a. MainActivity = 3D Printing

Independent Samples Test[a]

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
Likely to Return	Equal variances assumed	.606	.440	-1.418	56
	Equal variances not assumed			-1.549	45.098

Independent Samples Test[a]

		t-test for Equality of Means	
		95% Confidence Interval of the Difference	
		Lower	Upper
Likely to Return	Equal variances assumed	-1.532	.262
	Equal variances not assumed	-1.461	.191

a. MainActivity = 3D Printing

MainActivity = Magnetic Slime and Slick Activity

Group Statistics[a]

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Likely to Return	M	4	5.25	.957	.479
	F	6	5.50	1.871	.764

Independent Samples Test[a]

	t-test for Equality of Means		
	Sig. (2-tailed)	Mean Difference	Std. Error Difference

Independent Samples Test[a]

Likely to Return	Equal variances assumed	.814	-.250	1.027
	Equal variances not assumed	.789	-.250	.901

a. MainActivity = Magnetic Slime and Slick Activity

Independent Samples Test[a]

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
Likely to Return	Equal variances assumed	.891	.373	-.243	8
	Equal variances not assumed			-.277	7.716

Independent Samples Test[a]

		t-test for Equality of Means	
		95% Confidence Interval of the Difference	
		Lower	Upper
Likely to Return	Equal variances assumed	-2.618	2.118
	Equal variances not assumed	-2.342	1.842

a. MainActivity = Magnetic Slime and Slick Activity

```
GET
  FILE='C:\Users\Nick\Desktop\SPSS Parent Logbook.sav'.
DATASET NAME DataSet2 WINDOW=FRONT.
DATASET ACTIVATE DataSet1.
DATASET CLOSE DataSet2.
```

Supplemental Material E

Activity Decision Matrix

Supplemental Materials E

Activity decision matrix

Below is the decision matrix we used to decide which activities to develop. All initial activities that resulted from brain storming are included.

Activity	Cost	Equipment	Difficulty/timefr	Takeaway	CSIRO	(Physics,	Safety	Total
Chromatography	1	1	0	1	1	1	1	5
Testing toothpaste	1	1	1	1	1	1	1	6
Solar Cookers	1	1	0	1	1	0	1	4
Lava Lamps	1	1	0	1	0	1	1	4
DIY EKG	1	1	1	1	1	1	1	6
Rollarcoaster	1	1	1	0	1	1	1	5
All terrain wheelchair R&D	1	0	1	1	1	0	1	5
IDing an unknown	1	0	1	0	1	1	1	5
Make a Telescope	1	1	0.5	1	1	1	1	5.5
Wing going into a fan	1	0	0	1	0	0	1	3
Car (Homopolar motor)	1	1	0.5	1	1	1	1	5.5
Putt Putt Boat	1	1	1	1	0	0	0	3
MagnetoGravity Slingshot	1	0	1	1	1	1	1	6
trebuchet	1	1	0	1	0	0.5	1	3.5
heliostat balloon	1	1	0	1	0	0	1	3
3D Printed Bridge Contest	1	1	1	1	1	1	1	6
3D Printed Bike helmet	1	1	0	1	0	0	1	3
3D Printed Quadcopter	0	1	0	1	1	1	1	4
Restriction Enzyme Analysis	0	1	0	0	1	1	1	3
Modeling Bacterial Transformation	1	1	0	1	1	1	1	5
Design your own propeller clock	0	1	0	1	0	0	1	2
Design your own digital clock/watch	0	1	0	1	0	0	1	2
Make your own flashlight	1	1	0	1	0	0	1	3
Rockets/water bottle rockets	1	1	1	1	1	1	1	6
Molecular Gastronomy (Ice Cream, Can	1	1	0.5	1	0	1	1	4.5

Supplemental Material F

Spacecraft Activity Bill of Materials

Supplemental Material F

Below is a list of all the materials that were used to develop the Astronomy spacecraft activity.

Item	Quantity	Supplier	Notes (eg order takes 6 weeks to arrive)	Unit cost
Duct Tape	4 rolls	Bunnings		$3.65
Cardboard Boxes	20	Bunnings		$1.99
Paper Towels	3 rolls	On site		$0.00
Plastic Table cloth	4 meters	Bunnings		$2.00/meter
Bubble wrap	1 medium roll	Bunnings	Should be good for more than 1 camp	$9.94
Rubber Bands	2 packages	Office Works		$3.65
Cotton balls	2 packages	Woolworths		$1.60

Plastic Cups	30	Woolworths		$3.00/25
Aluminium Foil	1 roll	Woolworths		$2.83
Zip Ties	100	Bunnings		$8.14/100
Ziploc Bags	40	Woolworths		$2.35/40
PVA glue	500 mL	Bunnings		$10.70/500 mL
Disposable Measuring Cup	40	online	30 mLhttp://store.independenceaustralia.com/medicine-cup-30ml-disposable-pktx100.html	$4.79/50
Twine	1 roll	Bunnings		$3.00
Gasket Tape	1 roll	online	http://www.indrub.com.au/tapes/epdm-durafoam/tt6110-epdm-durafoam-closed-cell-epdm-durafoam-black-tape.html	$22.00
Paddlepop sticks	400	OfficeWorks		$3.50/160
Hot glue guns	4	On site		$0.00
Hot glue sticks	40	OfficeWorks		$3.50/12

Eggs	30	Woolworths		$4.59/12
9 V Battery	30	Jay Car	Discount if buy in bulk?	$2.00
Battery Case	30	eBay	http://www.ebay.com.au/itm/New-9V-Volt-PP3-Battery-Holder-Box-DC-Case-with-Wire-Lead-ON-OFF-Switch-Cover-/172175323885?hash=item281672f2ed:g:xWcAAOSwkEVXGExo	$1.00
220 Ohm Resistor	30	Jay Car	Discount if buy in bulk	$0.48/2
LED light	30	Ebay	http://www.ebay.com.au/itm/3mm-LED-Bulb-Red-Pack-of-50-WS-/321791569478?hash=item4aec45ae46:g:8dYAAOSwjVVVi7vL	$1.00/50
Heat sensor	30	http://measuretech.com.au/non-reversible-thermax-label-strip/22-thermax-temperature-strips.html		$34.43/50
Electrical tape	1 roll	Jay Car	Discount if you buy in bulk	$2.95
TESTING MATERIALS				
Fan	1	Bunnings		$14.98

Small rolling cart	1	Bunnings		$4.00
Rulers	30	On site		$0.00
Heat Gun	1	Bunnings		$21.97
Step Ladder	1	On site		$0.00
Meter Stick	1	On site		$0.00
Medium plastic tub	2	On site		$0.00
Stopwatch	3	eBay	http://www.ebay.com.au/itm/Best-selling-Chronograph-Digital-Timer-Stopwatch-Sport-Counter-Odometer-Watch-CC/332032201819?_trksid=p2045573.c100505.m3226&_trkparms=aid%3D555014%26algo%3DPL.DEFAULT%26ao%3D1%26asc%3D39923%26meid%3D50b5e14e4d0b4460827eb82e7b18fe63%26pid%3D100505%26rk%3D1%26rkt%3D1%26	$2.50
Scissors	30	On site		$0.00
Permanent markers	15	Office Works		$8.90/4
Vacuum	1	On site		$0.00
Sand	1 kg	Bunnings		$6.00/3Kg

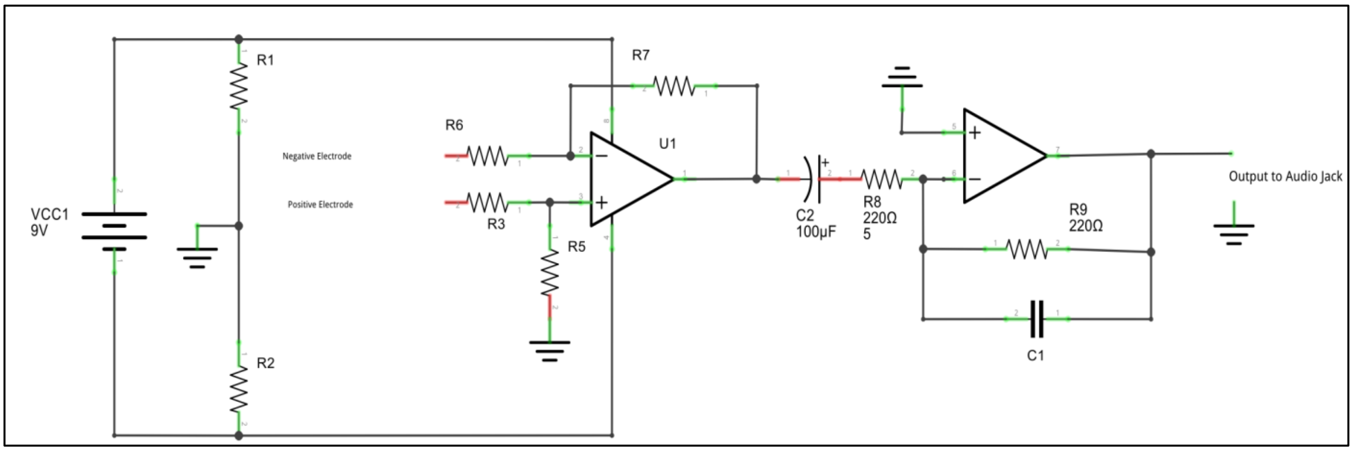
Medium plastic box with lid	1	On site		$0.00
Safety and take home handouts for students		Carly will send these to you		$0.00
			Sub total	$406.55
			+ 10% for unexpected costs	$40.65
			TOTAL COST	$447.20

Supplemental Material G

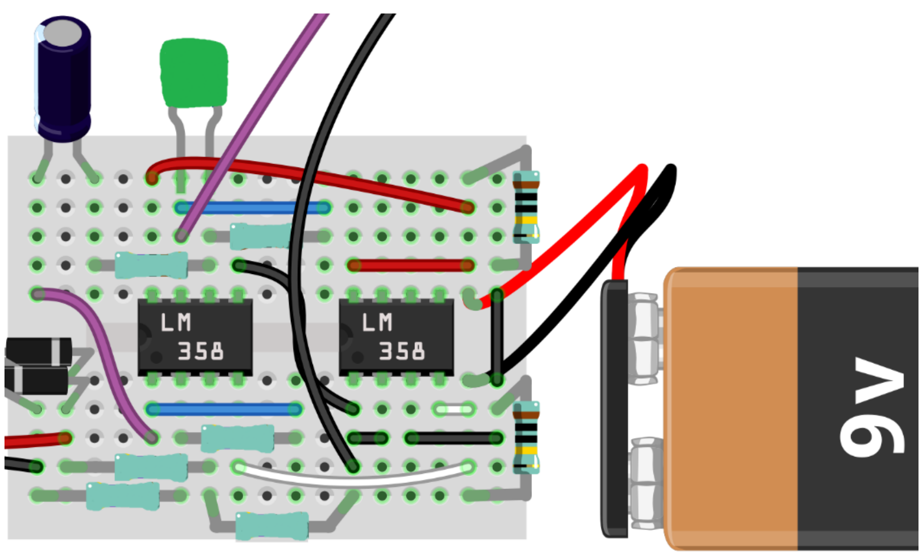
Initial Electrocardiogram Designs

Supplemental Material G

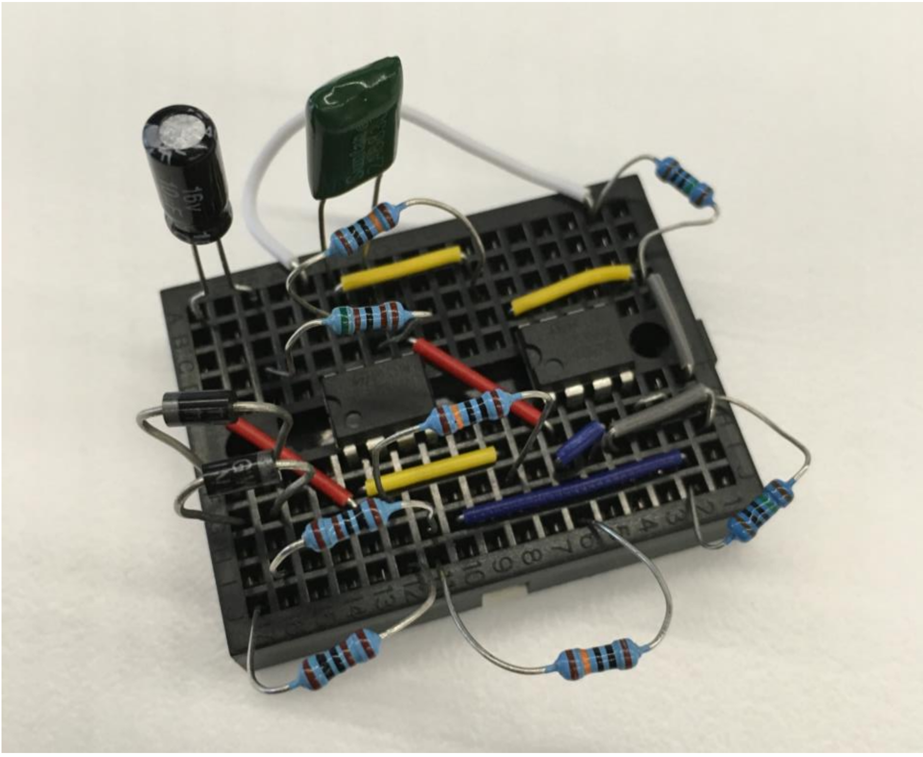
Initial designs for the ECG activity



Schematic design used for initially building the circuit



Fritzing design used for instructions



Full build of design

Supplemental Material H

Images of Spacecraft Activity Peer Testing

Supplemental Material H

Below are images of peers testing the activities for clarity and enjoyment.

Astronomy activity

Jake and Morgan explaining the astronomy activity to Nicole and Gui.

Gui designing his spacecraft

Lucas building his spacecraft.

A peer's space craft undergoing the aerodynamics test.

Toothpaste activity

Jeremiah preparing a tile to test the stain removal ability of toothpastes.

Lucas, Zack, and Jeremiah testing the abrasiveness of different commercial toothpastes.

Zack testing the foaming ability of toothpaste.

ECG activity

Supplemental Material I

Astronomy Instructor Activity Template

www.csiro.au

Supplemental Materials I

Astronomy instructor activity template

CEdO Science Bootcamp

Space Exploration

November 2016

Contents

1. Two day overview

Day 1

Time	Activity/Event	Venue	Notes	Presenter roles	Example
9:00am – 9:45am	Setup for the day			Presenters 1, 2, 3 setup	GK Williams Room
9:45am – 10:05am	Doors open Student arrival		Students arrive Need something to entertain those on time or a space for them to congregate in. Science Hangman works surprisingly well.	Presenter 2 sign-in sheet Presenters 1, 3 in room with students	GK Williams Room
10:05am – 10:15am	Behavioural expectations and safety announcement (toilets, etc) Get to know you questions, icebreaker activities		See Educate file path: Public/Community Engagement/BC/BC admin and planning/BC icebreaker activities.pptx	Presenter 2 sign-in sheet Presenters 1, 3 in room with students	
10:15am – 11:30am	TBD				
11:30am – 12:00pm	Morning tea	Outdoors if weather permitting	Students provide their own recess		
12:00pm – 12:40am	Presentation – CSIRO researcher		20min talk, 15min Q&A	Presenters 1,2 supervising Presenter 3 on break (12:00 – 12:40)	
12:40am – 1:15pm	CSIRO Quiz			Presenter 1 on break (12:40 – 1:20pm)	
1:15pm – 2:00pm	Lunch	Outdoors if weather permitting	Students provide their own lunch	Presenter 2, 3 supervising	

2:00pm – 3:45pm	**Astronomy activity: Space and Astronomy background, spacecraft design, building and preliminary testing**		**See below for activities in detail with timeline**	**Presenter 1 gives presentation, both presenters float during building/preliminary test portion**	
3:45pm – 4:00pm	**Wrap up, clean up.**			**Presenter 1 sign-out sheet** **Presenter 2, 3 supervising**	**GK Williams Room**
3:45pm – 4:45pm	**Presenters clean up and re-set for day 2**			**Presenters 1, 2, 3 pack up**	

Day 2

Time	Activity/Event	Venue	Notes	Presenter roles	Example
9:00am – 9:45am	Setup for the day			Presenters 1, 2, 3 setup	GK Williams Room
9:45am – 10:05am	Doors open Student arrival		Students arrive Need something to entertain those on time or a space for them to congregate in. Science Hangman works surprisingly well.	Presenter 2 sign-in sheet Presenters 1, 3 in room with students	GK Williams Room
10:05am – 10:20am	Icebreaker activities		See Educate file path: Public/Community Engagement/BC/BC admin and planning/BC icebreaker activities.pptx	Presenter 2 sign-in sheet Presenters 1, 3 in room with students	
10:25am – 11:00am	Presentation – CSIRO researcher		20min talk, 15min Q&A	Presenters 1,2 supervising Presenter 3 on break 10:45-11:25	
11:00am – 11:20am	Morning tea	Outdoors if weather permitting	Need time to move to first lab tour	Presenter 1, 2 supervising Presenter 3 on break 10:45-11:25	
11:30am – 1:00pm	Lab tours		Either 2x lab tours with 15 students per lab (rotate) approx. 40min per lab (with walking time) OR 2x lab tours with 10 students per lab plus non-lab break with hologram activity.	All 3 presenters required	GK Williams Room
1:00pm – 1:45pm	Lunch		Students provide their own lunch	Presenter 1 on break (1:10 – 1:50pm)	Outdoors if

				Presenter 2 on break (1:50 – 2:30)	**weather permitting**
1:50pm – 3:40pm	**Astronomy Activity: Spacecraft final testing**		**See detailed activity breakdown for details.**	**Presenter 1 gives presentation, Presenter 2 is stays at heat resistance test station, and impact test station during testing, presenter 1 floats**	**GK Williams Room/outdoors weather permitting**
3:40pm – 4:00 pm	**Wrap up, clean up.**		**Thank you to presenters and students, evaluation forms filled in, items all collected.**	**Presenter 1 sign-out sheet Presenter 2, 3 supervising**	**GK Williams Room**
4:00pm – 4:30pm	**Presenters clean up**			**Presenters 1, 2, 3 pack up**	

2. Hands-On Activity Program Overview

Program name: Space Exploration

Developed by: Morgan Garbett, Nick Pratt, Jake Rivard, Kayla Sica

Date of bootcamp/s: TBD

Brief program outline (max. 2-3 sentences):

Students learn about extra-planetary communication, space travel, and materials and using this information to design, build and test their own spacecraft, which should successfully keep an "astronaut" safe as they subject the craft to through various tests.

Key concepts/points the program covers

Day 1

- The grand scale of the Universe, and what CSIRO is doing to learn more about many of its components
- CSIRO's global role in Astronomy
    - Their renowned radio telescopes, and what a radio telescope is
    - The research being done with receivers and signal amplifying systems
    - Applications of these technologies
    - Spacecraft tracking systems
    - Study of pulsars to learn about galaxy formation
    - Development space-related of technology used in daily life
    - Technology for communicating with spacecraft on missions and in orbit
- Stages of travelling outside of Earth's orbit and beyond
    - Launch
        - **TEST (aerodynamics)**, aerodynamics necessary to leave the atmosphere because otherwise it would require too much fuel
        - *Materials:* cart, fan, stopwatch, and ruler.
        - *Possible test:* "top" of spacecraft parallel to the table and the spacecraft laying on its side on the cart, place the cart 20 cm away from the fan with the "top" pointing toward it, let the fan run for 45 seconds and measure the distance it moved
        - *Possible positive outcome:* spacecraft does not move at all, overall the less it moves the better because the air is not exerting enough force on it

- Space travel
    - **TEST (air tightness)** oxygen is vital to life- spacecraft must be airtight, if water can get in air can get out, Air bubbles are gas escaping
    - *Materials:* stopwatch, bucket ½ filled with water, paper towels
    - *Possible test:* wrap the astronaut in a dry paper towel, then reseal the spacecraft and fully submerge in water for 30 seconds
    - *Possible positive outcome:* paper towel around egg comes out dry and no air bubbles come out of the craft while under water
    - **TEST (dust resistance)** try to keep dust out of space craft, Space craft must keep outside material from entering air vents/electrical components/living area because it can harm the devices and be harmful if breathed in
    - *Materials:* box filled with sand, scale, stopwatch
    - *Possible Test:* take the spacecraft's mass before placing in the box, record the value, place spacecraft in box, snap on the lid, and shake for 30 seconds, remove spacecraft, only knocking off sand directly on top/outside of the spacecraft, take its mass again and record the mass, determine the difference to see how much sand it took on.
    - *Possible positive outcome:* the less the mass of the spacecraft increases the better.
- Returning to Earth
    - **TEST (heat resistance)** Re-entry survival tested with heat test, gets very hot, must protect astronaut and electronics from these temperatures
    - *Materials:* heat gun, temperature sensors
    - *Possible Test:* "top" of spacecraft parallel to the table on protective plates, heat gun pointed at it for 90 seconds
    - *Possible positive outcome:* The heat sensor does not change color
    - **TEST (impact test)** Landing survival tested with impact test, landing is difficult because of the speed it reaches
    - *Materials:* step ladder, instructor, meter stick, stopwatch, plastic bags for eggs
    - *Possible test:* put the egg in a plastic bag, point the "top" of spacecraft pointing down dropped from a height of 2 meters off the ground
    - *Possible positive outcome:* the egg does not break
- Communication
    - CSIRO helps with radio telescopes
    - **TEST (communication)** communication light must be on and visible at all times, important to keep in contact with Earth
    - *Materials:* electrical tape, LED light, one 220kΩ resistor, one 9V battery
    - *Possible successful communication*: seal connections (LED to resistor, LED to battery, resistor or battery) with hot glue
    - *Possible positive outcome*: the light stays on throughout all of the tests

- Overview of requirements:
    - Must have a door

    - Must pass all 6 tests (aerodynamic, heat, dust, airtightness, impact, and communication)
    - Must use only $1000 or less when "purchasing" materials for design
    - No larger than 30cmx30cmx30cm
    - Able to hold and protect an egg (astronaut) throughout testing process
    - Cannot use a normal plastic bag

Day 2

- Review of previous day, how it went
- CSIRO story on materials
    - Work with Boeing
    - Application of materials for both planes and spacecraft
    - Makes it easier
- Testing review
- Logistics for first half
- Outcomes discussion
    - How successful were you
    - Was it what the students expected
- CSIRO story – WiFi
    - Astronomers studying pulsars discovered algorithm (formula)
    - Radio signals were able to relate

3. Activity Timeline

Day 1. 120 minutes

Time (min)	Event	Notes
0 – 15	**Presentation**	• Astronomy and CSIRO background • Launch profile of a spacecraft • Guidelines and criteria for students' spacecraft
16-30	**Spacecraft Design**	• Students spend a minimum of 15 minutes reviewing the given materials and drawing out a design on their worksheet
31-100	**Build spacecraft, Perform preliminary testing if desired**	• Students purchase materials from shop, use them to build their spacecraft • If the student would like to, they may run preliminary tests on their design (ex. See if a certain material will hold up under the heat gun, or remain water-proof)
101-110	**Clean up**	• Store spacecraft and students materials in one confined area so no materials are mixed together. • Throw away trash, clean
111-120	**Discussion**	• Recap what worked/didn't work • What students learned, what was surprising

Day 2. 120 minutes

Time (min)	Event	Notes
0 –10	**Final construction of spacecraft**	• **Allow students more time to make changes in anticipation of them reflecting more on their design overnight and throughout the second day**
10-75	**Aerodynamics, Heat Resistance, and Dust Testing**	• **Students rotate between Aerodynamics testing and Heat Resistance testing**
75-100	**Impact and Airtight Testing**	• **Every spacecraft will need to be tested in the order of Impact, Dust, Airtight (underwater test) to avoid making a bigger mess than necessary**
101-110	**Clean up**	• Spacecraft will be wet, but students may still bring them home if they like
111-120	**Discussion**	

4. Risk Assessment

Type of hazard	Description of task or activity	Inherent Risk			Existing Controls	Residual Risk		
		High	**Medium**	**Low**		**High**	**Medium**	**Low**
Eye injury	Students may poke themselves in the eye with scissors or materials		X		- Have students wear safety glasses - Instructors should supervise students, ensuring they are being careful			X
Ingestion	Student consumption of a raw egg, or PVA glue			X	- PVA glue is safe if accidentally consumed - Warn students not to consume any materials, and to wash their hands after use			X
Stain	Markers may stain skin and clothing		X		- Instructors should supervise students, ensuring they are being careful			X
Burns	Glue gun use, blow dryer or heat gun use		X		- Instructors should supervise students, ensuring they are being careful - Correct usage instructions provided - Only instructor uses heat gun		X	

Slips, trips, falls	Walking around with liquid on floor			X	- All spills mopped up immediately - Students warned not to walk in the area - Walking only - Cords from glue gun, heat gun, or blow dryer			X
Electrocution	Some equipment (e.g. hair dryer or heat gun, hot glue gun) powered from a mains power supply		X		- All mains power electrical equipment will be tagged and tested (and tested annually) - Access to power points will be as restricted as possible within the limits of the room			X
Cuts/Stab wounds	Use of scissors		X		- Instructors should supervise students, ensuring they are being careful			X
Fumes	Putting materials in front of heat gun or hair dryer, especially gasket tape	X			- Instruct students to use caution, and supervise them to ensure they are being careful - Ensure heat gun is operated under 290 °C			X
Fire	Putting materials in front of heat gun or hair dryer		X		- Instructors should supervise students, ensuring they are being careful			X

					- Keep heat gun below 290 ºC - Carbon dioxide fire extinguisher necessary if gasket tape catches fire			
Power tool injury	A hole needs to be drilled in the lid of the bin for the dust test		X		- Only instructors should use the drill as necessary - Drilling should be performed during Bootcamp prep, when student attendees are not present - Instructors should wear safety goggles when drilling			X

5. Presenter notes/Activity details

5.1. Preparation for bootcamp

Pre-activity Setup

Day 1

Set up the shop, station 1, station 4, and station 5.

Day 2

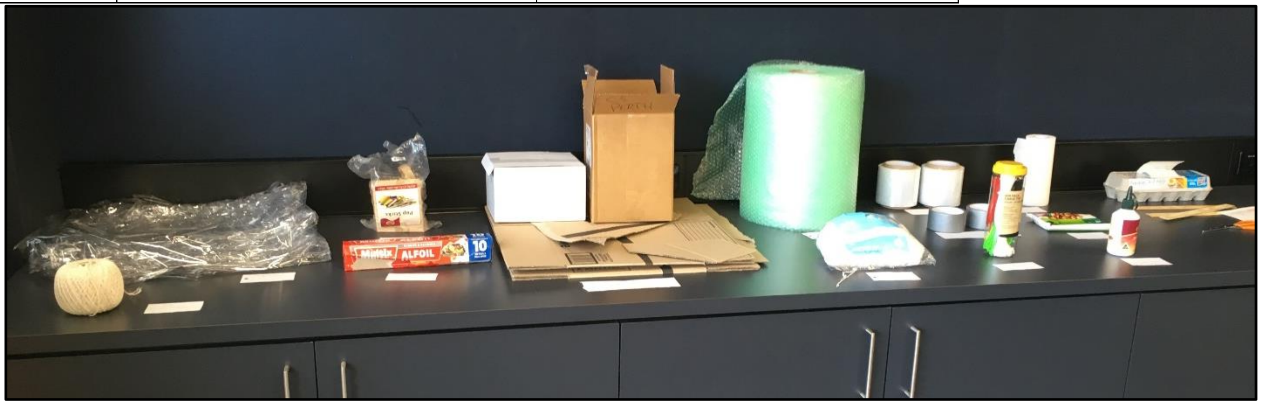
Set up the shop and all stations.

SHOP

Lay out all of the purchasable materials on a counter with the price tags in front of them. Remember to distribute heat sensors and the electrical array before the students start building.

Material	Price	Amount per Price
Duct tape	$12	1 meter
Cardboard	$250	Half of a box
Paper towels	$19	1 meter
Plastic sheet	$250	1 meter
Bubble wrap	$75	1 meter
Rubber bands	$1	1 rubber band
Cotton balls	$2	1 cotton ball

Cups	$150	1 cup
Aluminium foil	$2	1 meter
Zip tie	$4	1 zip tie
Ziploc bag	$3	1 bag
Glue	$3	1ml glue
Twine	$3	1 meter
Gasket tape	$255	1 meter
Paddle pop sticks	$3	1 stick
Shrink Wrap	$3	1 meter
Hot Glue Stick	$50	1 stick



Test Stations

Lay out the materials for each test at a station around the room, as shown in these pictures.

Station 1: Aerodynamics Test

Materials

- Cart
- Fan

Logistics

- Students can operate this test themselves

Example Test

The spacecraft is placed on the cart and the fan is blown at it, the shorter the distance the cart moves the more aerodynamic the spacecraft is.

Station 2: Heat Test

Materials

- Heat Gun
- Protective Ceramic

Logistics

- Instructor must be the one using the heat gun
- Make sure that the wood board are used to keep table from getting too hot

Example Test

A heat sensor is placed on the egg and the spacecraft is placed on the wood board. The heat gun is then used to heat up the spacecraft, if the sensor gets triggered it did not keep the astronaut cool.

Station 3: Drop Test

Materials

- Stepladder

Logistics

- Instructor must be the only one to climb the stepladder

Example Test

The student asks the instructor to climb onto the stepladder and drop the egg. If the egg is broken, the astronaut would not have survived.

Station 4: Dust Test

Materials

- Tub with 3kg of sand inside it to begin
- Scale

Logistics

- Put the sand in the tub before the day begins
- Make sure that the lid is on the tub whenever the tub is being moved
- Students can operate this test themselves

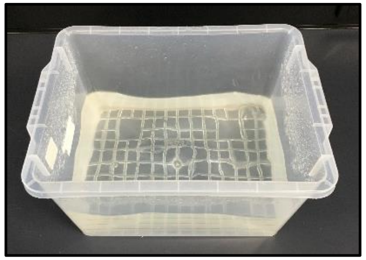
Example Test

The spacecraft is weighed, and then placed inside of the closed tub with sand. The tub is shaken and the spacecraft reweighed to see how much sand got stuck in it. The lower the increase in weight, the more resistant to dust the spacecraft is.

Station 5: Airtightness Test

Materials

- Tub filled half way with water



Logistics

- Fill tub with water before the day begins
- Students can operate this test themselves

<u>Example Test</u>

The students hold the spacecraft underwater for a set amount of time such as 30 seconds. If water gets into the spacecraft, it was not airtight.

5.2. Day 1: Spacecraft Design, Building, and Preliminary Testing

<u>Outline</u>

1. Scenario, criteria, and rules included in presentation. Ensure the final slide with this information is left up as students work on the activity
2. Allot a minimum of 15 minutes for students to draw out their designs, and review (but not purchase) available materials
3. Purchasing of materials - students may come back and purchase materials again as many times as they like, budget permitting, throughout the activity
4. Building/preliminary testing - Presenters should be prepared to assist students with preliminary testing of materials as they build (i.e. see if a material will remain structurally sound during the heat resistance test, or if a seal will remain watertight during the 'airtightness' test

5.1.2. Building the Spacecraft

<u>Presenter Instructions</u>

In this science activity, students will work individually to design, build and test a spacecraft that will protect an egg through an impact test, heat test, water-tightness test, and aerodynamics test.

- After the presentation of activity guidelines and objectives, students should take approximately 15 minutes to draw out a design for their spacecraft before purchasing materials. Students will likely want to look at the given materials, which should be laid out with their cost labeled. **Have students join communication array together using electrical tape and twisting wires.**

Discussion at end of day

Discussion Questions

- Did your spacecraft turn out exactly how you designed it? If not, why?
- What requirements did you find the most challenging? Why?
- Did you do any preliminary tests? If so, what did you learn?

Safety Warnings

During construction, remain vigilant about the following risks

- Cuts from scissors or sharp edges on materials. Make sure scissors are used properly and not as Stanley knives.
- Shorting out the battery for the LED circuit, or directly connecting the positive and negative wires. Make sure the resistor is used otherwise LED will get very hot and blow.
- Keep Glue guns in one section and have students move to glue gun, not move the glue gun to their bench space.

5.3. Day 2: Spacecraft Testing

5.2.1. Testing Logistics

The testing will be split up into two portions for ease in classroom management. The first portion will be the heat resistance, aerodynamics, and dust tests. Student groups will design their own testing procedures and choose pass/fail criteria based on given testing equipment.

First half: Heat, Aerodynamics, Dust

- Students split into 4 groups (let them know what they will be doing first). See chart below to let them know what the rotations will be.

Group	Min 10-20	25-35	40-50	55-65
1	Aero	Prep (design all tests)	Dust	Heat
2	Heat	Aero	Prep	Dust
3	Dust	Heat	Aero	Prep
4	Prep	Dust	Heat	Aero

- **There must be a presenter handling the heat-gun test.**
- Each group designs how they want their tests to be run within presenter designated limits (which may change depending on your space)
- Students get 5-10 minutes to design the first test
- The set-up for a test may change depending on the group's idea for the test, so modifications may be needed when the groups switch.
- Every member of the group must have a job when testing: i.e.(aerodynamics) holding the fan steady, placing the spacecraft at the correct initial distance, watching the distance the spacecraft moves, timing, recording observations, and supervisor.
- For the groups that do not test first, they can start designing their next test.
- When a group finishes the test they were doing they get 5 minutes to design their next test.
- If all groups are moving faster than 10 minutes for each test, let them move ahead
- When a group finishes testing they now have that time to analyze the data they collected, reflect on the test, and relate their results to the real world in the chart in their instruction sheets.
- One instructor is using the heat gun, the other floats between other groups

Second Half: Impact and Airtight tests

- Students stay in same four groups as before
- All groups have 10-15 minutes to design both tests, then first group starts
- One instructor is with the impact test, one is floating
- Again, everyone must play a role in testing: i.e. (impact) hand off to instructor, timing to fall, measuring height, observers, person who record effects
- Once the first group is done they will move onto the airtight test.

- There should be 2 stations (buckets of water) for the airtight test, so two groups can be running that test at once
- Groups begin the sequence as the one before them finishes.
- While groups are waiting, they can continue modifying their spacecraft
- Once a group completes the entire sequence they should look at the recorded data and fill in their chart on the outcomes of their testing and what the real-world outcome would be. Once that is finished they should clean up their station if there is a mess.
- They can then continue the additional activities if they have time. (the instructions for those are below)
- If time allows the instructor can create a chart about how many spacecraft passed the tests and how many astronauts survived and what design elements successful/unsuccessful ones had to open up a discussion about what would have made the "best" spacecraft.

If this takes too long the dust test can be taken out

Discussion Questions

- Did your eggstronaut survive? Why or why not?
- What test was the most difficult to pass? Why?
- What test was most difficult to design? Why?

5.1.2. Aerodynamics Test

The goal of this test is for students to learn more about how aerodynamic their spacecraft is. They are given the materials listed below. The intention is that students will arrive at the conclusion that the spacecraft should be placed on the cart, with the 'leading edge' facing towards the fan. Here the leading edge is the side or point that would lead to the best aerodynamic properties (e.g. a point, or skinnier part of the craft), but students can make the choice of side they want facing forward. If the wind from the fan exerts enough force on the spacecraft, it will move. This movement demonstrates that the spacecraft is not very aerodynamic. Different testing methods that accomplish the same goal are acceptable. Some instructor guidance to arrive at a suitable testing procedure might be necessary. Students must decide upon quantitative measures of their testing procedures so that the same test can be replicated, and record these measures and all other associated information within each row on the table in their worksheet. For example, such quantitative measures could be as follows: distance between spacecraft and fan, and maximum acceptable movement of the cart and spacecraft.

Materials

- Fan
- Rolling cart
- Ruler
- Stop watch

Safety Warnings

- Don't let students put fingers in the fan,
- Be aware of electrical issues.

5.2.2. Heat Resistance Test

The goal of this test is for students to see how well their spacecraft can insulate its cargo. They are given the materials listed below.

The intention is that students will arrive at the conclusion that the spacecraft should be placed with the leading edge facing towards the heat gun, with the wooden plates protecting the table from the heat gun's heat, and one heat sensor stuck to the egg. Different testing methods that accomplish the same goal are acceptable. Some instructor guidance to arrive at a suitable testing procedure might be necessary. Students must decide upon quantitative measures of their testing procedures so that the same test can be replicated, and record these measures and all other associated information within each row on the table in their worksheet. For example, such quantitative measures could be as follows: precisely where each sensor will be placed on the spacecraft, how far away the heat gun will be held away from the spacecraft, and how long it will be run for.

Materials

- Heat gun
- Wooden heat protective plates
- Two heat sensors
- Stopwatch

Safety Warnings

- The heat gun should only be operated by the instructor.
- Students should stay clear of the heat, and their spacecraft, as it may release fumes or catch fire

5.2.2. Dust Resistance Test

The goal of this test is for students to see how well their spacecraft can keep dust particles out of its interior. They are given the materials listed below. The intention is that students will arrive at the conclusion that the spacecraft should be weighed both before and after being put in the dust bin, to determine how much dust the spacecraft took on. Different testing methods that accomplish the same goal are acceptable. Some instructor guidance to arrive at a suitable testing procedure might be necessary. Students must decide upon quantitative measures of their testing procedures so that the same test can be replicated repeatedly, and record these measures and all other associated information within each row on the table in their worksheet. For example, such quantitative measures could be as follows: how much an acceptable amount of dust for the spacecraft to collect is, how long the spacecraft will be in the dust bin.

Materials

- Bin filled with sand
- Fan/Vacuum cleaner on reverse - either is acceptable, depends on equipment availability
- Scale
- Stop watch

Safety Warnings

- Students should not put hands in fan.
- The lid to the bin should always be closed before the fan/vacuum is turned on.
- The student operating the fan/vacuum should wear safety glasses

5.2.2. Impact Test

The goal of this test is for students to see how well their spacecraft can protect its cargo in an impact test simulating a ground landing. They are given the materials listed below. The intention is that students will arrive at the conclusion that the spacecraft should be held, then dropped at a predetermined height with the impact resistant side facing the floor. Different testing methods that accomplish the same goal are acceptable. Some instructor guidance to arrive at a suitable testing procedure might be necessary. Students must decide upon quantitative measures of their testing procedures so that the same test can be replicated repeatedly, and record these measures and all other associated information within each row on the table in their worksheet. For example, such quantitative measures could be as follows: how far away from the ground each spacecraft will be held.

Materials

- Step ladder
- Meter stick
- Ziploc bags to put eggs in (does not contribute to the spacecraft "costs" with student budget)

Safety Warnings

- Only the instructor should be standing on the step ladder
- Students should stand clear of "drop zone"
- Eggs must be put in ziploc bags before testing, as raw eggs might crack

5.2.2. Air-Tightness Test

The goal of this test is for students to see if their spacecraft will be airtight in the vacuum of space. They are given the materials listed below. The intention is that students will arrive at the conclusion that the spacecraft should be fully submerged underwater for a predetermined amount of time. Note to students: bubbles while the spacecraft is submerged is not the most accurate way to test for water tightness because aluminum foil and other materials may bunch up and trap air. Different testing methods that accomplish the same goal are acceptable. Some instructor guidance to arrive at a suitable testing procedure might be necessary. Students must decide upon quantitative measures of their testing procedures so that the same test can be replicated, and record these measures and all other associated information within each row on the table in their worksheet. For example, such quantitative measures could be as follows: how long the spacecraft will be submerged underwater for.

Materials

- Water tank
- Stop watch
- Paper towels

Safety Warnings

- Students should only submerge the spacecraft underwater with one hand, because of the LED circuit in each spacecraft.

5.2.3 Extra Activities for when students finish early

Create your own Lunar Lander

- Students will create their own shock absorbing lander from the materials used for the spacecraft
- Students are allowed to redesign
- The same eggs will be used for their test subject
- Leave handouts at the front of the room and students can get them once they have completed all of the spacecraft data analysis

Universe expansion activity

- Students will learn about how the universe is expanding using a balloon and markers
- Concept is to understand galaxies are always moving apart
- Leave handouts at the front of the room and students can get them once they have completed all of the spacecraft data analysis

6.0 CSIRO Stories

- Radio telescope tracking spacecraft
    - https://publications.csiro.au/rpr/pub?list=SEA&pid=csiro:EP123474&sb=RECENT&expert=false&n=5&rpp=25&page=1&tr=14&q=Spacecraft&dr=all
    - Radio telescopes help track things in space, especially with the Deep Space Network
    - CSIRO has worked with NASA on many occasions to communicate with and track interplanetary missions

  - Australia has the most NASA tracking facilities outside of the US
  - Helped with Apollo lunar missions and Viking mars landings
  -
- Worked with Boeing to create process that heat shields are applied with
  - http://www.csiro.au/en/Research/MF/Areas/Chemicals-and-fibres/Materials-for-industry-and-environment/Coatings-and-surfaces/Plasma
  - Determined how to use plasma to create a process to apply materials to surfaces
  - More economical and efficient than traditional methods
  - Modifies chemical and structural properties of a material to be able to apply it in this way.
  - Used to apply ceramic layer to spacecraft
  -
- Involvement in GRACE Follow-On mission
  - http://www.csiro.au/en/Research/Astronomy/Spacecraft-tracking-and-space-science/Space-sciences-and-technology
  - Used high-precision manufacturing techniques to aid building of the craft
  - Improved quality and possible lifespan of spacecraft
  - the craft will replace the original GRACE in orbiting the Earth
  -
- Spacecraft heat materials monitoring tool
  - https://publications.csiro.au/rpr/pub?list=SEA&pid=csiro:EP128799&sb=RECENT&expert=false&n=4&rpp=25&page=1&tr=14&q=Spacecraft&dr=all
  - Created a structural monitoring system to detect damages
  - Developed because spacecraft heat shields are vulnerable to damage from objects in space
  - Able to detect, locate, and assess damage
  - Uses an acoustic emission sensor network - uses sound wave feedback to determine where damage is
  -
- Space Navigation using pulsars
  - https://publications.csiro.au/rpr/pub?list=SEA&pid=csiro:EP14486&sb=RECENT&expert=false&n=3&rpp=25&page=1&tr=14&q=Spacecraft&dr=all
  - The Parkes telescope has and continues to observe millisecond pulsars
  - Found taking 4 millisecond pulsar observations every 7 days can very accurately determine location within 20 km and velocity
  -

- Wifi and Pulsars
    - http://www.csiro.au/en/Research/D61/Areas/Wireless-and-networks/Wireless-broadband/WiFi
    - CSIRO invented wifi
    - Radio-physicists determined how to “smooth” out the signal and let it be organized when it got to your device
    - Used algorithms that were used to decode emissions from black holes (pulsars too)
    - Used everywhere today

7.0 Equipment List (any leftover materials can be reused for the next bootcamp)

Item	Quantity	Supplier	Notes (eg order takes 6 weeks to arrive)	Unit cost
Paper	60 sheets		For designing spacecraft on	$0.00
Duct Tape	4 rolls	Bunnings	Purchase	$3.65
Cardboard Boxes	20	Bunnings	Or appropriate from elsewhere – much better idea!	$1.99
Paper Towels	3 rolls	On site		$0.00
1.25L empty soft drink bottles	10	From staff?	Try not to buy them as they aren't in the budget. We can cut them out as an option but if anyone in the office drinks such things get them to bring the empty bottles in between now and the BC.	
Plastic Table cloth	4 meters	Bunnings	This is a relatively thickish plastic table cloth not your standard cols supermarket piece of breakable stuff.	$2.00/meter
Bubble wrap	1 medium roll	Bunnings	Should be good for more than 1 camp Purchase	$9.94
Rubber Bands	2 packages	Office Works	Purchase	$3.65

Cotton balls	2 packages	Woolworths	Purchase	$1.60
Plastic Cups	30	Woolworths	Purchase	$3.00/25
Aluminium Foil	1 roll	Woolworths	Purchase	$2.83
Cable Ties	100	Bunnings	Purchase	$8.14/100
Ziploc Bags	40	Woolworths	Purchase	$2.35/40
PVA glue	500 mL	Bunnings	Purchase	$10.70/500 mL
Disposable Measuring Cup	40	online	30 mLhttp://store.independenceaustralia.com/medicine-cup-30ml-disposable-pktx100.html	$4.79/50
String	1 roll	Bunnings	Purchase/Find (it doesn't have to all be the same type, if you have a variety offer a variety)	$3.00
Gasket Tape 18mm	1 roll	online	http://www.indrub.com.au/tapes/epdm-durafoam/tt6110-epdm-durafoam-closed-cell-epdm-durafoam-black-tape.html Purchase a role please	$22.00
Paddlepop sticks	400	OfficeWorks	You may already have. Also available online.	$3.50/160

Hot glue guns	4	On site	Find	$0.00
Hot glue sticks	40	OfficeWorks	Purchase more if needed	$3.50/12
Eggs	30	Woolworths	Purchase	$4.59/12
Battery snap for 9V	30	Jaycar	Carly to get in bulk	
9 V Battery	30	Jay Car	Discount if buy in bulk? Tell Carly if you have any as she has plenty	$2.00
220 Ohm Resistor	30	Jay Car	Discount if buy in bulk. Carly will purchase	$0.48/2
LED light	30	Ebay	http://www.ebay.com.au/itm/3mm-LED-Bulb-Red-Pack-of-50-WS-/321791569478?hash=item4aec45ae46:g:8dYAAOSwjVVVi7vL Tell Carly if you don't have any and she will purchase more	$1.00/50
Heat sensor	30	http://measuretech.com.au/non-reversible-thermax-label-strip/22-thermax-temperature-strips.html	Carly already has, don't purchase	$34.43/50
Electrical tape	1 roll	Jay Car	Discount if you buy in bulk. Carly to purchase	$2.95

TESTING MATERIALS

Fan	1	Bunnings	Find something	$14.98
Small rolling cart	1	Bunnings.	Or you may have in thinking scientifically etc. Any sort of lightweight wheeled cart would do, rubberband car or similar. Should run relatively easily. Pretty sure you will have something. I'm using a rubberband car (I think)	$4.00
Rulers	30	On site		$0.00
Heat Gun	1	Bunnings	Maddy, don't buy this I will bring one from Melbourne.	$21.97
Step Ladder	1	On site	For presenter to stand on for impact testing. Or nice height from somewhere	$0.00
Meter Stick	1	On site		$0.00
Measuring tapes	3	On site		$0.00
Medium plastic tub	2	On site	For water testing. Want something slightly bigger than a box of A4 paper box. Kids can make their craft up to 30cm long so something longer and deeper for submersion.	$0.00
Stopwatch	3	On site	May need more, see how many you can find.	$0.00
Scissors	30	On site		$0.00

Permanent markers	15	Office Works	Or have fewer so they can share, see what you have around	$8.90/4
Sand	1 kg	Bunnings	Don't get propagating sand as it shouldn't be breathed in. Get from the beach if available.	$6.00/3Kg
Medium plastic box with lid	1	On site	For dust testing. A kit box with lid would be fine	$0.00
Safety and take home handouts and instruction sheets for students			In Folder on Educate	$0.00
			Sub total	$404.05
			+ 10% for unexpected costs	$40.41
			TOTAL COST	$444.46

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AT CSIRO WE SHAPE THE FUTURE

We do this by using science to solve real issues. Our research makes a difference to industry, people and the planet.

As Australia's national science agency we've been pushing the edge of what's possible for over 85 years. Today we have more than 5,000 talented people working out of 50-plus centres in Australia and internationally. Our people work closely with industry and communities to leave a lasting legacy. Collectively, our innovation and excellence places us in the top ten applied research agencies in the world.

WE ASK, WE SEEK AND WE SOLVE

FOR FURTHER INFORMATION

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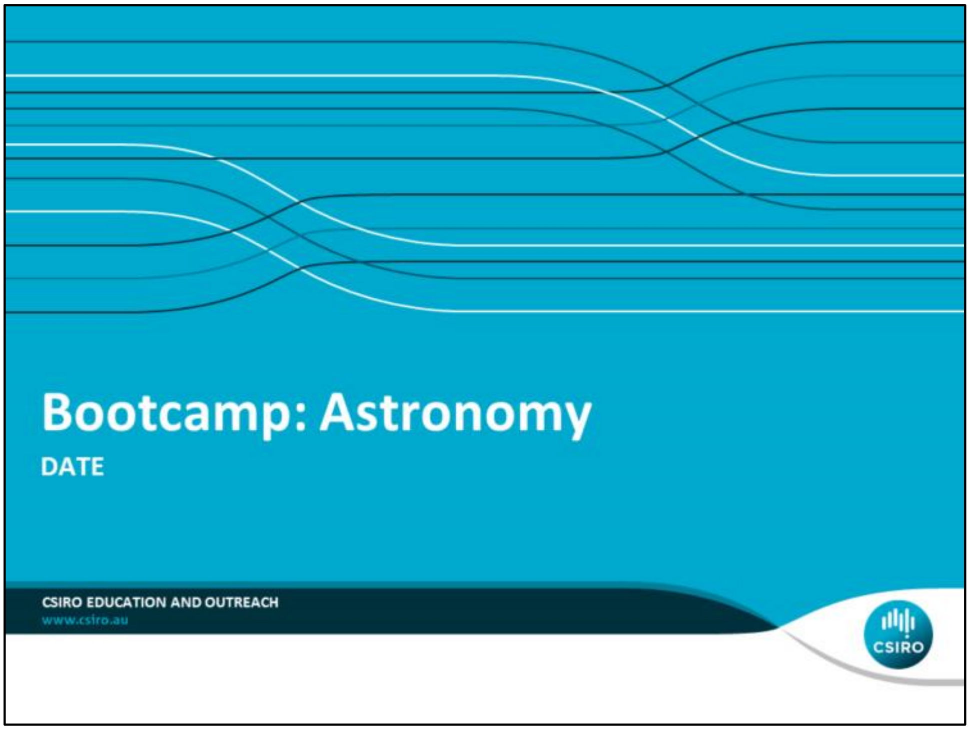
Supplemental Material J

Presentations for astronomy bootcamp


Bootcamp: Astronomy
DATE
CSIRO EDUCATION AND OUTREACH
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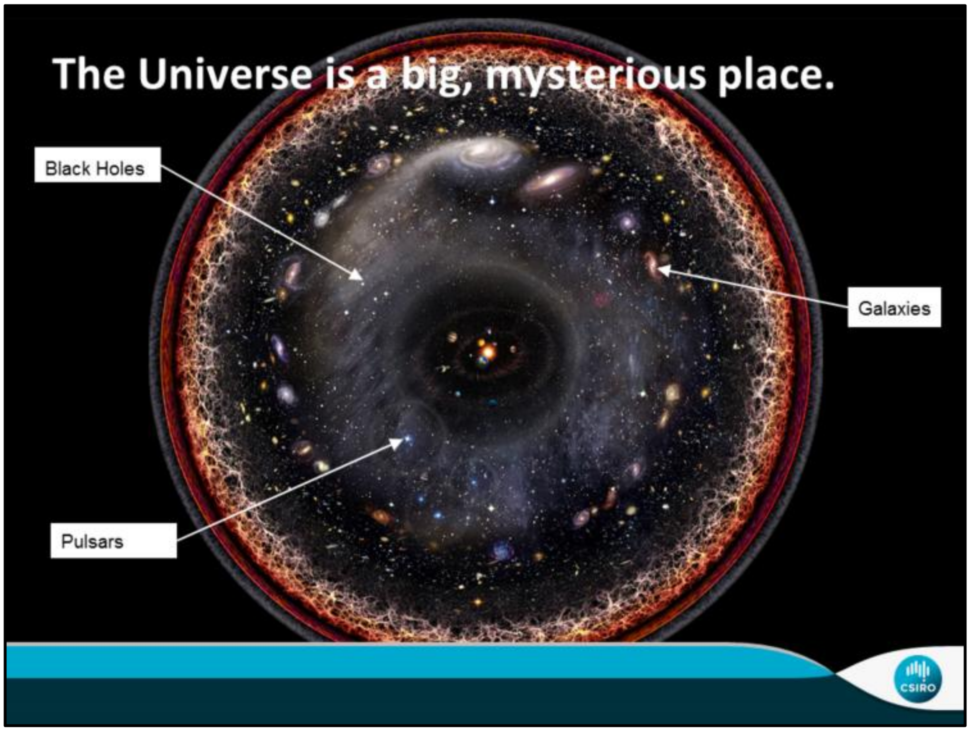


The observable universe--or every part of the universe humanity can detect, is enormous. It is 93 billion light-years across, meaning that even if we travelled as fast as light, it would take us over 46 Billion years to travel to the outer edge. Humanity will likely never travel to most of the universe, but through sophisticated scientific techniques and equipment, CSIRO and other scientific agencies are able to observe the various black holes, galaxies, pulsars, and other space things that make up the universe. Because of the broad expanses of space between galaxies and solar systems, astronomers can even look back in time billions of years to see the history of the universe.

main points:

- The Universe is Extremely Big
- We can observe it because of sophisticated technology
- So far away that we look back in time
- Our current frontier, the moon

How do they do all this? For starters, CSIRO manages all of Australia's leading observatories, which operate a number of radio telescopes. A radio telescope detects and amplifies radio waves from space, turning them into signals that astronomers use to understand more about the universe. CSIRO also works to develop new technologies for radio telescopes that allow astronomers to see further than ever before, including new radio receiving technologies, and signal processing systems. While this research may seem very far off and removed from our everyday lives as people, it helps with many relevant things.

Main points:

- CSIRO manages all Australia's observatories
- Radio telescopes help astronomers to understand the universe through signals
- CSIRO innovating new technologies to improve information
- Relevant (next slide)

CSIRO contributes to everything from the search for extraterrestrial life, to the discovery and observance of over 1000 pulsars, which are small cores of collapsed stars that emit beams of radio waves. They use radio telescopes to learn about the structure and star formation process of our own galaxy, galaxies in the nearby universe, and the evolution of galaxies in the distant universe. This has helped to create images of galaxies and allowed much more knowledge to be learned about the world we live in.

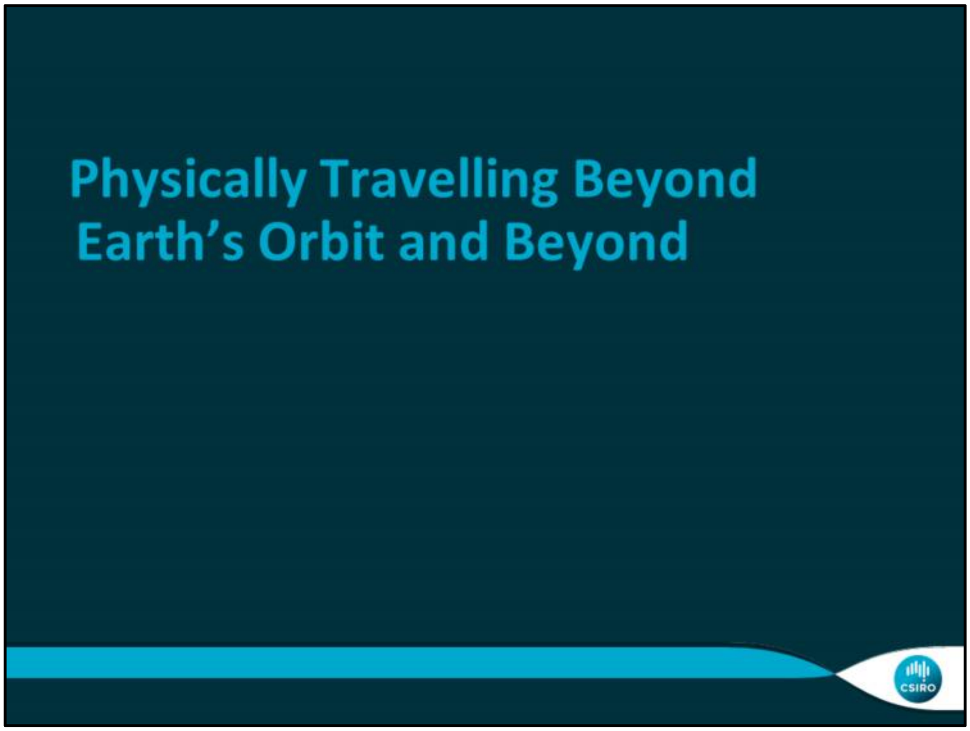
main points:

- CSIRO is integrated into every aspect of space discovery
- observes pulsars
- used to hypothesize how our galaxy was formed

CSIRO works with NASA to track spacecraft in orbit. this started in 1962 when the Australian Parkes radio telescope was used to receive signals from NASA's Mariner 2 spacecraft. CIRO's radio telescopes received Apollo 11 signals when the first people walked on the moon. They helped televise the landing also. Today, We manage and operate the Canberra Deep Space Communication Complex at Tidbinbilla, one of three tracking stations around the world that make up NASA's Deep Space Network. Together, the three stations provide around-the-clock contact with more than 40 spacecraft, including missions to study Mars, Venus, Jupiter, Pluto, the Moon and the Sun

Main points:

- CSIRO works with NASA to track spacecraft and receive signals
- Helped when the first people walked on the moon
- Today part of the Deep Space Network that maintain contact with spacecraft on missions



Now, you have all been tasked as the scientists and engineers who will build a spacecraft on a mission to another planet. There are many important aspects to space travel, that you must consider, and challenges involved. Your goals include:

- Successful launch and aerodynamics
- Space travel with human luggage
- Safe reentry and thermal shielding
- Surviving rough landings
- Protecting communication instrumentation

This is a hypothetical representation of a manned mission to another planet.

Goal: interest students in what they are about to do

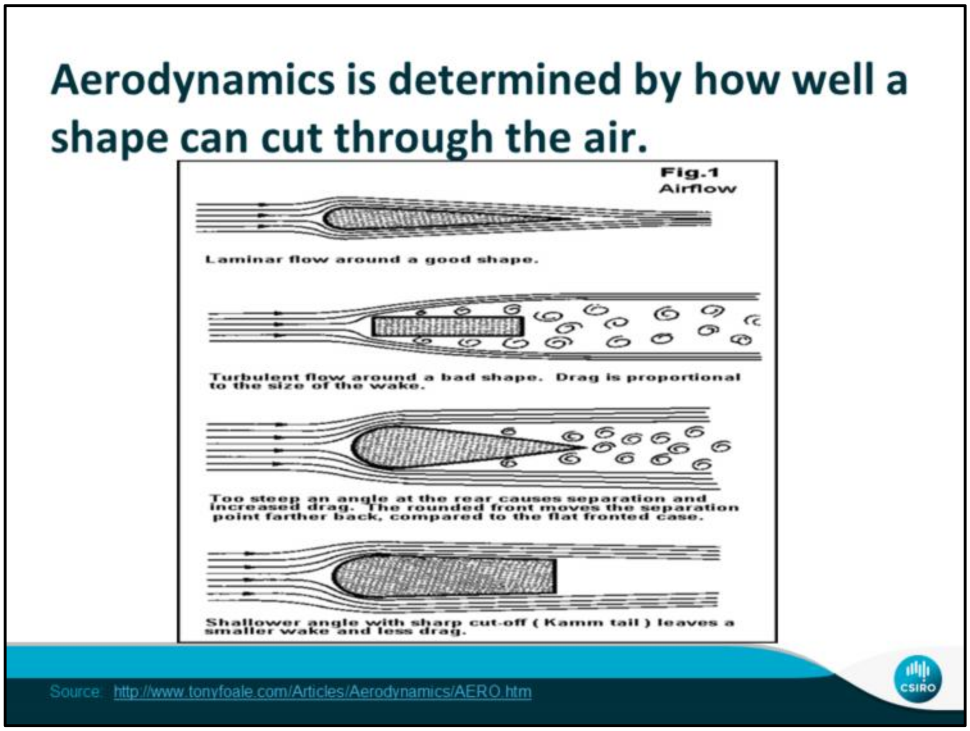
The difference between a hypothetical manned mission and the reality of a rocket to the moon or an unmanned probe is that the unmanned probe does not have as stringent of requirements because it does not need to create an environment to sustain human life. Therefore, it is lighter and costs less. If you are talking about what the students are creating in particular, an unmanned probe does not need a door and does not need to be airtight for example.

One difficulty of manned space travel is the launch of the spacecraft. As you can see, it takes a tremendous amount of force to push a spacecraft into the air and make it escape the atmosphere. Most spacecraft use huge amounts of fuel; for instance, each booster on the space shuttle burned almost two million liters during this launch. In order to reduce forces on the spacecraft as it passes through the air, making the launch safer and reducing the fuel construction, the leading edge, or front side of the spacecraft during launch must be aerodynamic.

The reason why the spacecraft must escape the atmosphere is because the atmosphere provides a lot of air resistance to the spacecraft and the spacecraft uses a lot of fuel to do this.

main points:

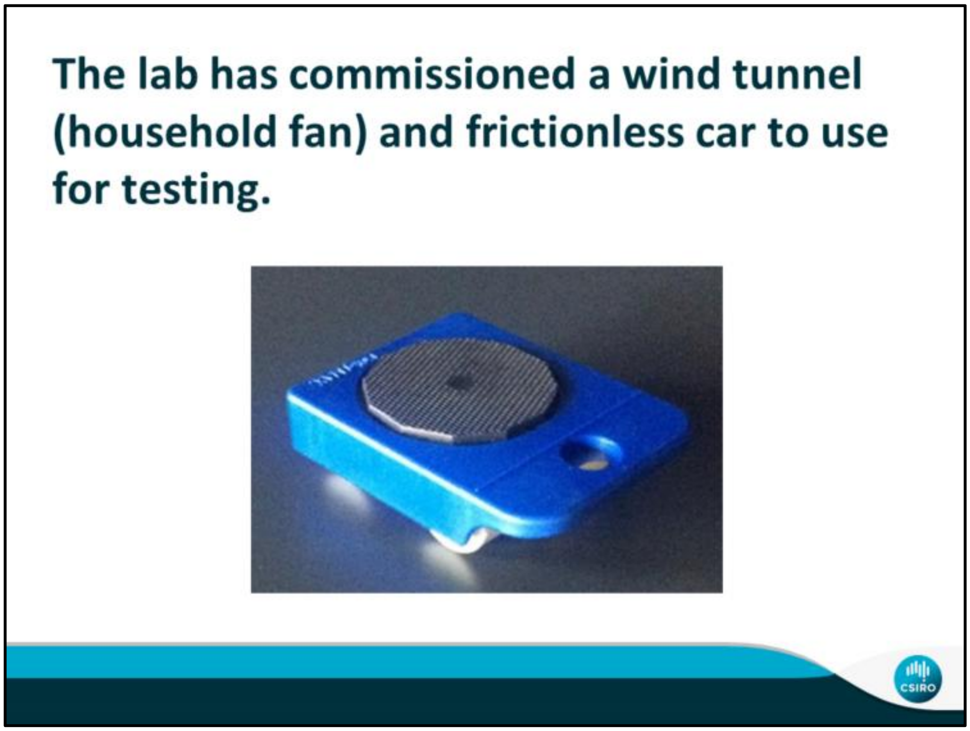
- Launch is difficult
- Spacecraft must be aerodynamic
- Atmosphere provides air resistance slowing down spacecraft. Spacecraft needs to reach certain speed to escape the atmosphere.
- Aerodynamics while in space is irrelevant, but is important for launch and re-entry



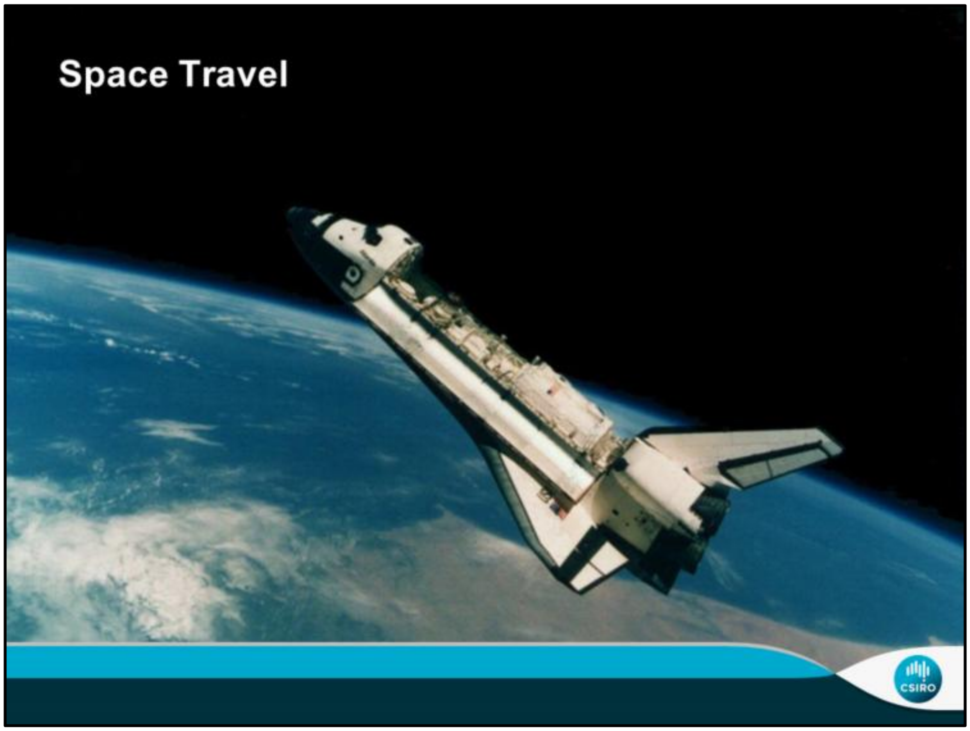
When something is aerodynamic it moves through the air easily with little force against it. The shape of something that goes through the air helps to determine how aerodynamic the object is. When the tip of an object has a large surface area, such as the larger cone or the rectangle, more air pushes against it creating a force that holds it back from moving forward. As you saw in the last picture it takes a lot of force to leave the atmosphere. That is why being aerodynamic is important beacause engineers want as little working against the spacecraft as possible.

main point:

- Shape of your spacecraft is important
- Consider both ends of the spacecraft, not just the front/top of the craft.



Your group is to design a test to determine if your spacecrafts are aerodynamic using these tools.



The vacuum of space presents many challenges to people. People need air to breathe, water to drink, and food to eat, none of which is available in outer space. A spacecraft’s secondary job is to bring people to outer space, but it’s primary impact is to keep those people alive. It must preserve an environment in which people can live.

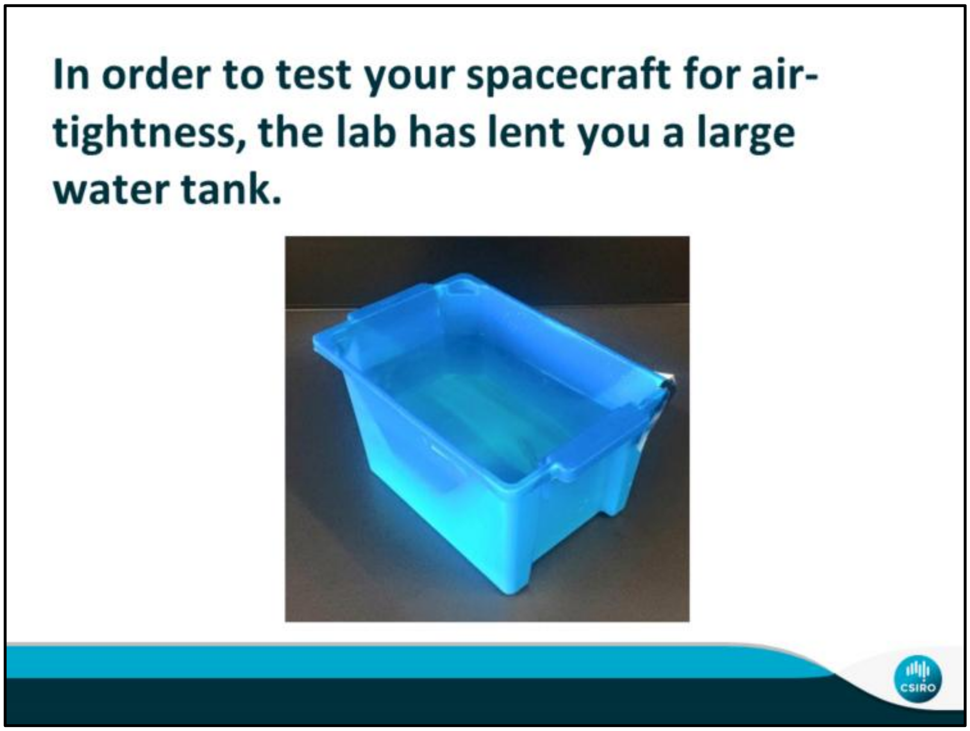
main point:

- There is no oxygen or other things necessary for life in space
- People need oxygen to stay alive

In a spacecraft, it is vital that oxygen stays inside of the spacecraft and does not escape. Space is a vacuum, so if there was an opportunity for gas to escape the spacecraft, it would be sucked out. In order to avoid this, the spacecraft must be airtight. This means that when the spacecraft is completely sealed, nothing can get in or out of it, including air.

Main points:

- One of the most important things people need to survive is oxygen.
- In order to keep people alive, it must keep the air inside, and the vacuum of space outside.



The lab did not have a vacuum chamber available, so another way to test for airtightness is using water. How exactly is up to you. Air molecules are very small, smaller than water, so where ever water can get into your spacecraft, air can escape from. This test could also determine if your spacecraft is up to standard for a water landing, which happens very often when a spacecraft is coming back to Earth.

Main point:

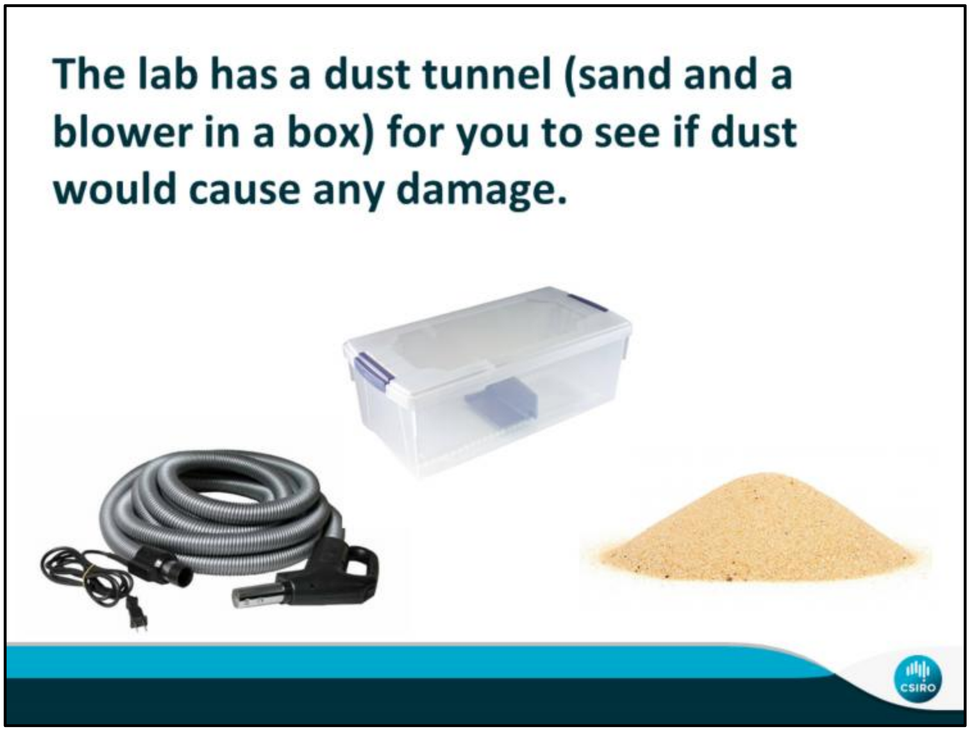
- Students have to determine how to use a water tank to test for airtightness.

A spacecraft integrates many different systems and they are all sensitive.

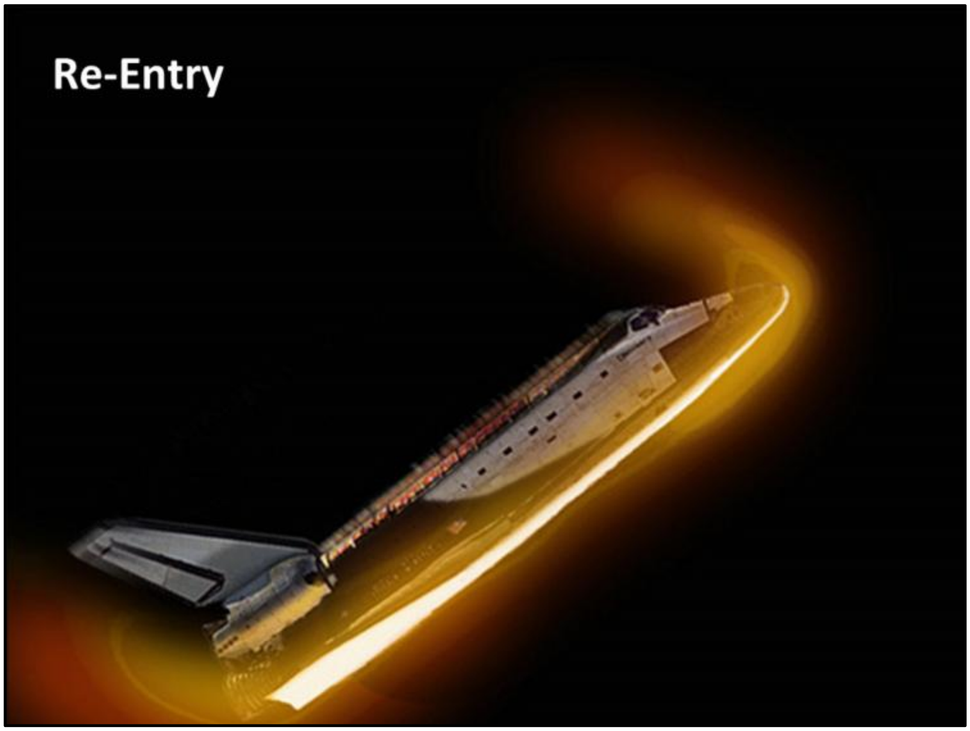
The electronics, communication, and air vents are only a few of the systems where small particles could affect them.

In many different terrains there is different kinds of dust and to keep the spacecraft functional, this unknown dust must be kept out of the spacecraft.

If dust was to get into the systems, the air could become contaminated and the astronauts could inhale something that is not good for them, or the electrical or other circuits could get interfered because of material getting crusted on them. This would cause communication and functional issues in addition to the health issues.



Students are to design an experiment to test how good their spacecraft is at keeping dust out of it. They have a “dust tunnel” (sand and a blower (vacuum on reverse) in a container with a lid), a stopwatch, and a scale

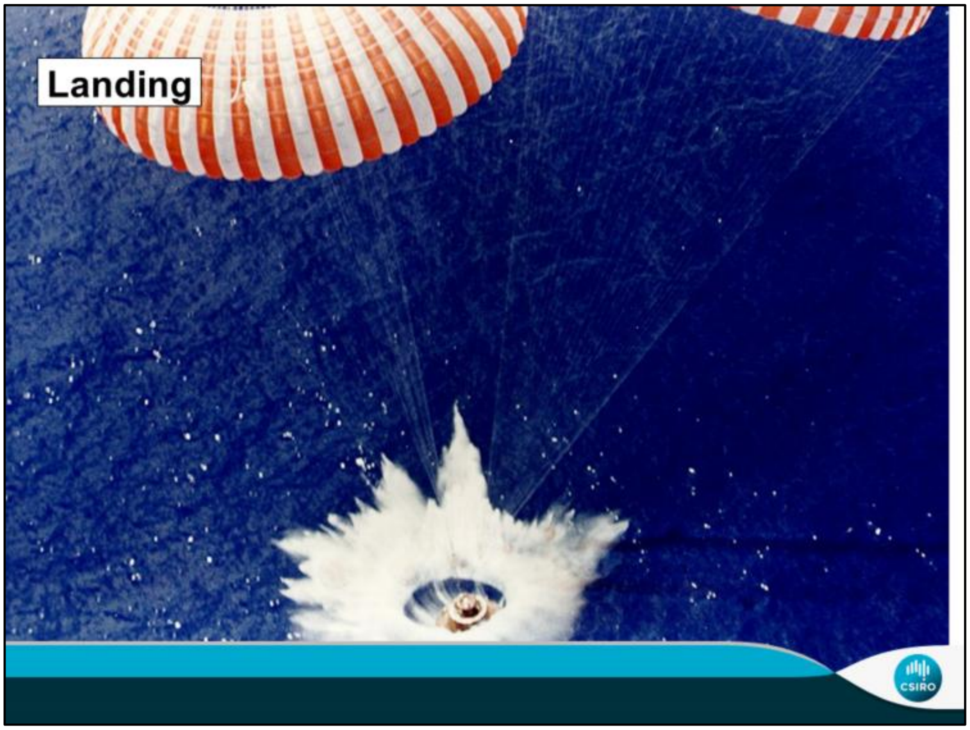


One of the harshest environments a spacecraft faces is re-entry into the atmosphere. It approaches at very high speeds, up to mach 25 (25 times the speed of sound), when it reaches the outside of the atmosphere. The spacecraft must slow down to a reasonable speed before either landing on a runway or splashing down into the ocean. When the air strikes the spacecraft, it instantly heats up to 1650°C, necessitating the need to protect the astronauts and craft itself from excess heat. They use composite tiles to insulate against this heat.

Main points:

- Space Shuttles have to deal with 1650C when they reenter earth's atmosphere.
- The astronauts but be shielded from this heat

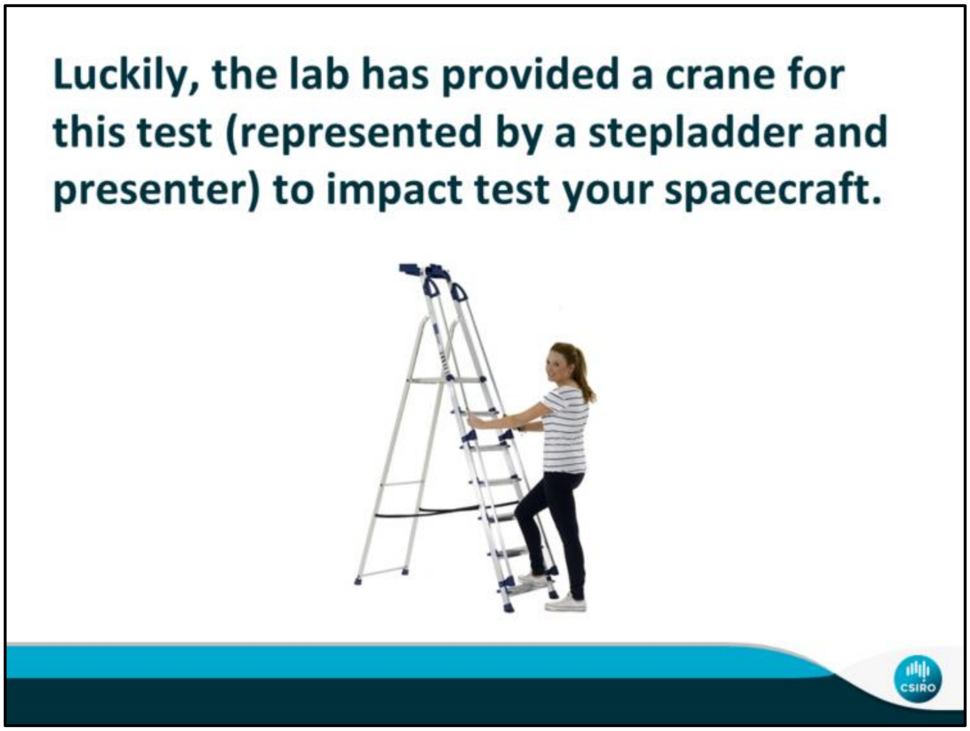
Students must design a test to determine if their spacecraft is insulated enough to keep the eggstronaut safe during landing using temperature sensors and a heat gun (only used by the instuctor)



Actually landing a spacecraft on earth safely is a very difficult task to accomplish. In this situation, your spacecraft actually does not want to be aerodynamic because it needs the air resistance to slow down. On Earth some spacecraft use parachutes for this. Even though a spacecraft slows down before landing, the impact is harsh, and on mars this tactic does not work because of the thinner atmosphere.. It is important that the astronauts inside the spacecrafts are protected from this impact.

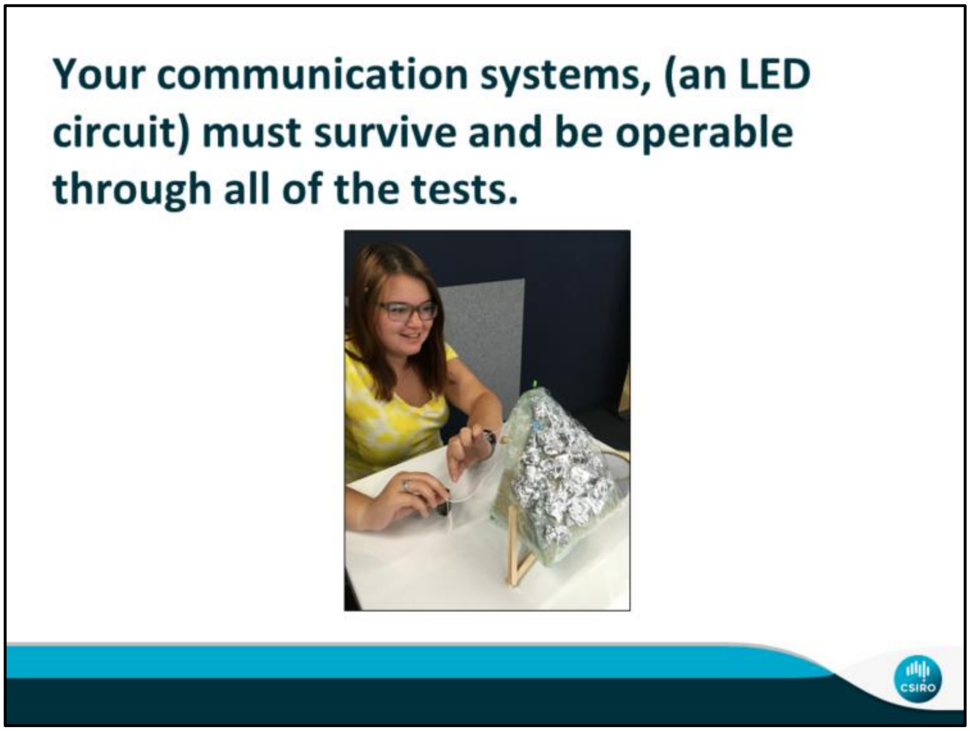
Main point:

- landing is dangerous
- Have to protect astronaut somehow

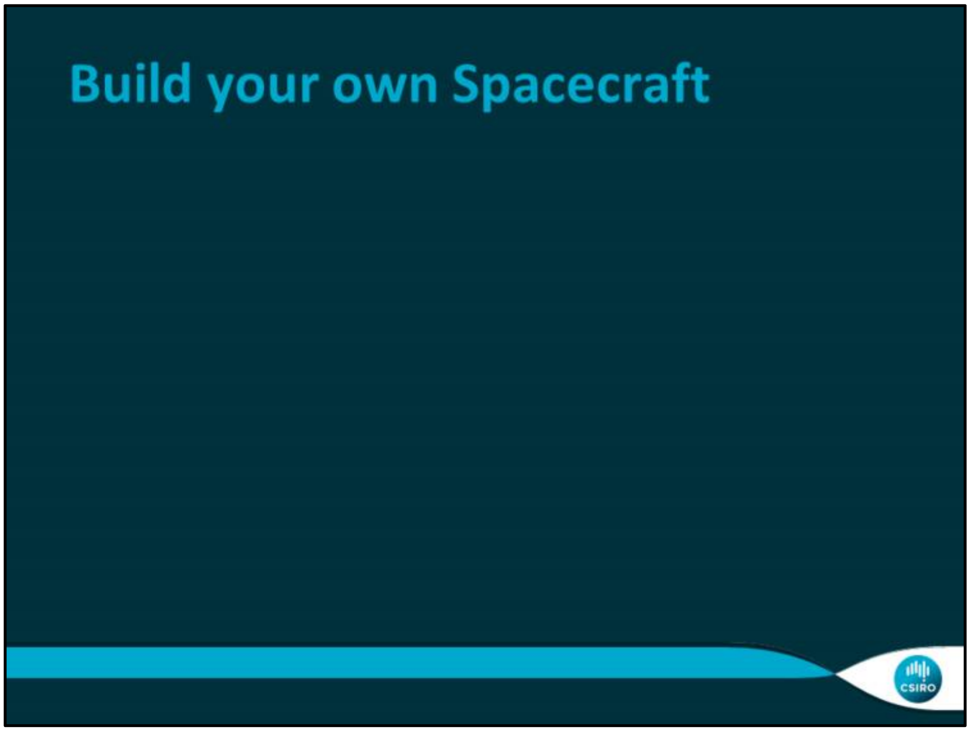


Students must design an experiment to determine how safe their astronaut is when the spacecraft lands using these materials.

In order for an astronaut to successfully complete his or her mission, he or she must remain in communication with mission control. CSIRO maintains the Deep Space Communication Network which has been used for several manned mission.



Students must determine how to keep the circuit on, visible, and protected through all the tests. THey may use any materials that are in the store.



Now, you have all been tasked as the scientists and engineers who will build a spacecraft on a mission to another planet. There are many important aspects to space travel, that you must consider, and challenges involved.

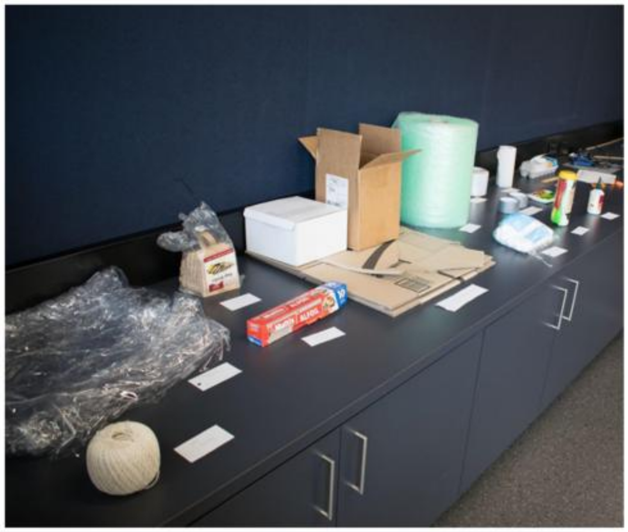
Criteria Overview

The spacecraft must

- Fit within a **30cm x 30cm x 30cm** cube
- Have a **resealable door** for the egg astronaut
- Have a lit up **LED** visible from the outside of the spacecraft at all times
- Be **aerodynamic** and **heat resistant** on the same side of the spacecraft (leading edge)
- Be **impact resistant** enough to protect an egg on another side
- Be **airtight**
- Unmodified Ziploc bags must not be used

This slide should be left up during the build period

Materials for your spacecraft be purchased with your budget of $1000



The “shop” contains all the materials that can be used to construct your spacecraft. Materials are purchased by unit,which can be found in your chart, as well as on the labels by the material. You can go to the store as offten as you would like, but cannot exceed your budget of $1000.

Might be better to include pictures of “materials store”

Bootcamp: Astronomy Day 2

DATE

Review

- What were the design requirements?
- What are the most challenging aspects of a spacecraft's journey?

Lead a quick discussion on what happened yesterday. The students started building, how did it go?

Yesterday, we talked about how on re-entry the surface of spacecrafts can reach 1650°C. Because of this high temperature it is very important that the materials used to protect the spacecraft are chosen carefully because each material has different characteristics, such as melting point and insulation ability. Usually spacecraft have ceramic on the outside of them to protect against this heat. CSIRO developed a technique to be able to spray the ceramic on like a liquid to make construction easier. Also, they worked with Boeing to create PaintBond which is used to allow a new layer of topcoat (the outermost layer that protects planes from the harsh environment at high altitudes) to be applied to an aircraft without sanding the old layer down.

- PaintBond: http://www.csiro.au/en/Research/MF/Areas/Chemicals-and-fibres/Materials-for-industry-and-environment/Coatings-and-surfaces/TopCoat
- Spray technique: http://www.csiro.au/en/Research/MF/Areas/Chemicals-and-fibres/Materials-for-industry-and-environment/Coatings-and-surfaces/Plasma

Main point:
- CSIRO does a lot of research on materials
- Materials could be used on spacecraft
- Material choice is very important

Tests

- Heat resistance test
  - Stopwatch, heat gun, protective plates, two heat sensors
- Aerodynamic test
  - Fan, rolling cart, ruler, stopwatch
- Dust protection
  - Bin with sand, vacuum on reverse, scale, stopwatch
- Impact test
  - Step ladder, meter stick, plastic bags to put egg in (no cost)
- Airtightness test
  - Water tank, stopwatch, paper towels

CSIRO

Review of what tests are to be completed and what students have to work with. All details are in the template.

Group Order

Group	Min 10-20	25-35	40-50	55-65
1	Aero	Prep	Dust	Heat
2	Heat	Aero	Prep	Dust
3	Dust	Heat	Aero	Prep
4	Prep	Dust	Heat	Aero

Order the groups are going to complete the first round of testing. Refer to the template for more details. After showing this slide students should start designing their first test.

Outcomes

Refer to the template for closing discussion questions

Remember the pulsars we talked about yesterday? A group of CSIRO astronomers who were studying pulsar found that the algorithms they invented to decode pulsar signals was exactly what they needed to make wifi work. They needed to determine how to make data signals emit at different frequencies, so they did not interfere with each other when more than one was being sent. These scientists are the reason why wireless internet and cellular data work today and everyone can scroll through social media without a second thought.
****insert link here****

Thank you for attending!

Supplemental Material K

Student handouts for astronomy activity

Supplemental Materials K

Student handouts for the astronomy activity

Student Notes for Designing your Own Spacecraft

Objective: Design and build a spacecraft that will stand up to the following hazardous environmental tests.

Aims: Keep eggstronaut unharmed. Maintain communications array throughout tests

Communications array: To communicate with CSIRO personnel on Earth (represented by an LED, two resistors, and a battery).

Budget: $1,000

Criteria:

- Be no larger than 30cm x 30cm x 30cm
- Have a re-sealable door that can open and close without the need for more materials
- The LED must be on and visible at all times in the finished spacecraft (Communications array)
- Have a safe compartment for your eggstronaut
- Maintain an internal temperature of less than 29^{o}C
- Be air/water tight (not let any water in when submerged)
- Keep dust particles out
- Be aerodynamic
- Keep your eggstronaut safe during an impact test
- Cost less than or equal to $1000

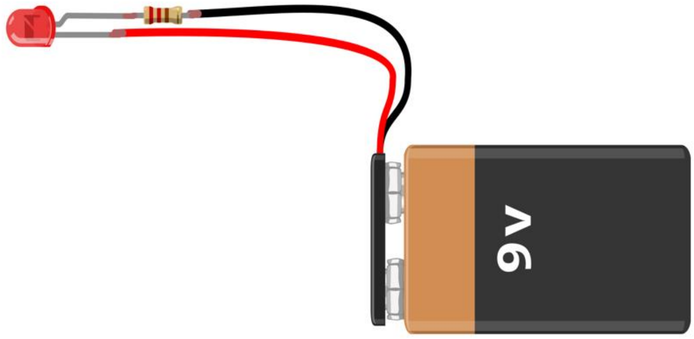
In groups you will design the testing procedure for each of the four tests: **Water-tightness, Dust resistance, Aerodynamics, Impact testing**. To design your tests fill in the information in the sections below, as well as the table at the end of this booklet.

Things to note:

- You are allowed to test your spacecraft or parts of your spacecraft before the final tests on Day 2.
- Keep in mind any preliminary testing will be done before the final tests are designed.
- If your spacecraft is destroyed in your preliminary testing, you will be responsible for paying to repair it with whatever is left in your budget. Good Luck!

Communications Array:

It is vital for the spacecraft to maintain communication with Mission Control at all times. Therefore, the LED communication light must remain on at all times. Build your communications array following the diagram below. Join components together with electrical tape. For best operation, the LED should stay dry because if it gets wet it may not work.

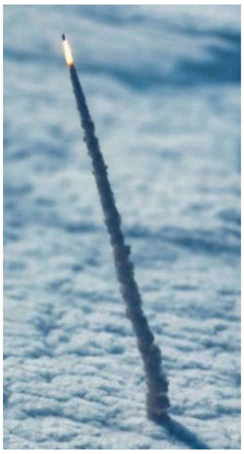


Draw your spacecraft design here.

Some things to keep in mind:

- Which side will be the leading edge of the spacecraft?
- Can the astronaut conveniently enter and exit the spacecraft repeatedly?
- How will you ensure that the LED is visible from outside the spacecraft but still protected?.
- How will you protect your eggstronaut from the heat and air?
- What materials can you use to do this?
- How do all of the tests work together?

Aerodynamics Test



You have been tasked with testing your design for aerodynamic feasibility. Design an experiment to test this using the materials the lab is providing.

Aim: Determine how aerodynamic your craft is

Available equipment:

- Nearly frictionless cart
- Wind tunnel (fan)
- Tape
- Stopwatch
- Measuring tape

Explain procedure	Sketch the arrangement

Ground landing

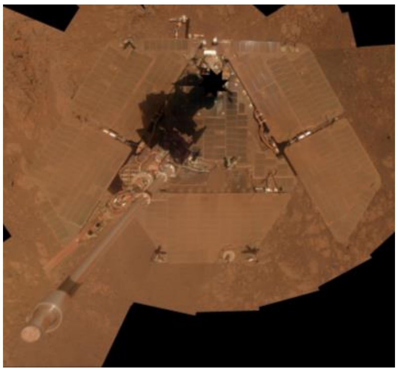
You must test your spacecraft for survivability in a rough landing back on Mars or back on Earth. It should be able to impact a liquid or solid surface at high speeds, for the sake of the safety of passengers. Design an experiment to test this using the materials provided.

Aim: Determine if your craft will survive solid impact with crew intact

Available equipment:

- Crane
- Crane operator (presenter)

Explain procedure	Sketch the arrangement



Dust Resistance:

Your spacecraft must be able to stand up to the harsh dust storms on the surface of mars. Luckily, the lab has created a dust chamber for your testing convenience. Design an experiment to test this using the materials provided.

Aim: Determine how much dust is taken onboard.

Available equipment:

- Dust chamber simulating Martian surface conditions
- Fan
- Measuring scales
- Stopwatch

Explain procedure	Sketch the arrangement

Air Tight:

Your spacecraft must be able to keep all of the air inside when exposed to the vacuum of space, just as it must keep it in the cabin of a real spacecraft travelling between planets. Submerging your spacecraft in water – or seeing if it is watertight – may help you understand how airtight it is. Design an experiment to test this using the materials provided.

Aim: Determine if your craft is air and water tight.

Available equipment:

- Water tank
- Crane operator (presenter)
- 1M ruler/measuring tape
- Stopwatch
- Paper towel

Explain procedure	Sketch the arrangement

Materials and Budget:

Like most real scientists and engineers, you have a tight budget ($1,000). The available materials are listed below, and can be purchased at the store. Keep track of your spending too. Luckily, a ruler and scissors have been provided for free.

Material	Price	Amount per Price
Duct tape	$12	1 meter
Cardboard	$250	Half of a box
Paper towels	$19	1 meter
Plastic sheet	$250	1 meter
Bubble wrap	$75	1 meter
Rubber bands	$1	1 rubber band
Cotton balls	$2	1 cotton ball
1.25L water bottle	$650	1 water bottle
Aluminum foil	$2	1 meter
Cable tie	$4	1 zip tie
Ziploc bag	$3	1 bag
Glue	$3	1ml glue
Twine/String	$3	1 meter
Gasket tape	$255	1 meter
Paddle pop sticks	$3	1 stick
Shrink Wrap	$3	1 meter
Hot Glue Stick	$50	1 stick

Budget

Material	Amount Purchased	Cost	Funds Remaining

Testing design and results

Test	Parameters	Allowable Change	Amount Changed in Preliminary Testing	Amount Change in Final Testing	Pass /Fail	Real World Effects
EXAMPLE: air tight	interior wetness	paper towel around the egg cannot get wet	center entirely soaked	interior completely dry	pass	if the interior had gotten wet, the oxygen would have escaped in space and the astronaut would have died.

Supplemental Activity 1

Universe Expansion

The universe is ever growing. It is expanding at a rate of 3.26 million light years. During this expansion, galaxies are moving further apart. In this activity, you will be able to visualize this concept of every aspect continuously in motion. Dots on the balloon will represent the galaxies and the balloon itself is the universe.

Procedure:

1. Gather a balloon, a strip of paper or twine, a ruler and a marker.
2. Blow into the balloon once.
3. Keeping the balloon inflated, make 10-15 dots on it.
4. Blow up the balloon to the size of your fist and observe what happens to the dots and then number them
5. Measure the distance between dot 1 and 10 other dots around it using any method and then record the distances in table.
6. Double the size of the balloon, but be careful not to pop it. Then, measure and record the distance between the same dots again in the table below.
7. Once the chart is completed, deflate the balloon and consider what would happen to this experiment in reverse

Dot number	Original distance from dot 1	Final distance from dot 1	Difference in distance
2			
3			
4			
5			
6			

7			
8			
9			
10			
11			

Supplemental Activity 2

Create your own lunar lander

Landing is one of the most difficult things a spacecraft has to do, as you saw in the activity you completed today. When a spacecraft is on its way to the moon it travels up to speeds of 29,000 km/hr. In order to keep the astronauts safe, it must slow down a lot. In this activity you must design a method of landing that will slow down the spacecraft enough and absorb the impact.

Design Requirements:

- Have a location for one astronaut to stay safely
- Not tip over when it lands

Design Process:

- Draft your lander design
- Build the lander
- Test the lander from various heights
- Revise the lander

When you are done designing and believe you have your final design you are ready for the final test. The final drop will be from 30 cm. If you are successful from this height, drop it from higher to see how well your lunar lander is built. After your last drop think about the following questions:

- Did your astronaut survive?
- What was successful or what went wrong?
- Was the outcome what you expected?

Astronomy take home notes material

What topic this bootcamp was on

Astronomy is the scientific study of the universe, space and the objects in it. This topic can be applied to space travel, as you learned during the Science Bootcamp; however, it can also explain occurrences on Earth, such as how the planet was made and what happened to the dinosaurs. Scientists today use astronomy to see if there is another planet in the universe that could support life as Earth does.

Space Exploration - Key Definitions

Aerodynamic - Having a shape that reduces the friction from air

Air resistance - The frictional force air puts against a moving object

Atmospheric Entry - The movement of an object from space through a planet's atmosphere to the surface

Ceramic - An inorganic, nonmetallic, solid material that is made up of metal, nonmetal, or metalloid atoms in ionic and covalent bonds

Composite Material- A material that is made up of two or more different materials with different physical or chemical properties that when combined have a brand new, unique set of properties

Heat shield - A device or coating for protecting against excessive heat

Light year - Astronomical distance equivalent to the distance that light travels in one year, 9.4607×10^{12} km

Pulsar - Stars that have collapsed and emit beams of radio waves

Radio Astronomy - The study of radio waves that come from celestial objects

Radio Telescope - A large device that is used to pick up radio waves from space that could come from either celestial objects, or from manmade satellites

Receiver - The equipment on a spacecraft or at mission control that receives and decodes the electromagnetic waves sent from the transmitter, so the messages can be understood

Transmitter - A set of equipment (in this case both at mission control and on the spacecraft) that creates and sends electromagnetic waves containing messages or signals, like radio waves

Vacuum - An area completely devoid of matter

Spacecraft

At the CSIRO Science Bootcamp you created your own spacecraft to travel to another planet and back to Earth. You used various materials to simulate the parts and subsystems that are used on objects travelling into space. The spacecraft was then tested on how well it would survive the rigors of space travel.

Improving your spacecraft

After completing the CSIRO Science Bootcamp, you learned about how your spacecraft would have survived on its mission. Now, think about how you could improve your spacecraft so that it can pass more tests. Look around your house, what can you find? Try to make another model of your spacecraft and see if it performs better than your original one.

Signals from Space Lend Information about other Environments

At the CSIRO Science Bootcamp, you created a spacecraft that could be worthy to explore space. Scientists such as astronomers and physicists, are continuously inquiring about how formation of objects occur. Spacecraft, analogous to the one you made, explore space and send signals back to Earth. On Earth, CSIRO has radio telescopes that receive signals both from spacecraft and from objects in space. The Parkes radio telescope detected a fast radio burst that was only a third of a millisecond long from an object that they believe is a billion light years away. Astronomers were able to analyze this signal and learn about the gas that is between galaxies. They discovered that the gas has weak magnetic fields and does not move with force, which is a hypothesis they had, but could not prove until now. Signals like this one come in every day and allow CSIRO to discover more and more about what is beyond Earth.

Information taken from 18/11/2016 news release “GALAXIES SAIL ON A TRANQUIL SEA, COSMIC FLASH SHOWS”

Space is big. Really, really big.

We all know that space is big. At the CSIRO Science bootcamp you learned about how the conditions faced by spacecraft make space travel hard. But what about distance? Does the sheer size of the universe make it difficult as well?

Equipment
String, Marker, Scotch tape, Tape Measure (although a ruler could work), and open space.

Method

1. Measure out 4.5 meters of string.
2. Choose one end of your string to be Earth, and mark a dot with the tape.
3. Try to measure 1/5 of a millimeter away from earth, and mark another dot here to be the Moon. How far away do you think the Moon is? _______
4. Draw a third dot for Mars 3 cm from earth as it is the closest planet to earth. How far away do you think Mars is? _______
5. The sun is the closest star to earth. Mark it as 8 cm from earth. How far away do you think the Sun is? _______
6. Neptune is the farthest planet in our solar system. Mark Neptune as 4 meters away from earth. How far away do you think Neptune is? ______
7. The second nearest star is one of the three in the Alpha Centauri star system (which one changes as they rotate around), and is going to be 21 km away from earth on your string. How far away do you think it is in space? ______
8. Call SpaceX and charter a flight on a spaceship to Mars. Go about a quarter of the way there, or about 12.6 million km away from earth on your string. Mark this as Andromeda, the nearest galaxy to earth. Radio mission control to them you've changed your mind and would like to come back. Or don't. The activity is over anyways. How close do you think this really is? _______

Safety issues

- Do not call SpaceX or attempt to fly to Mars.

Answers
Moon: 384,400 km
Mars: 54.6 million km
Sun: 149.6 million km
Neptune: 7.5 billion km
Alpha Centauri: Averages 4.01*10^13 km
Andromeda Galaxy: 2.37*10^19 km

CSIRO connections

See how CSIRO used astronomy to invent wifi
http://www.csiro.au/en/Research/D61/Areas/Wireless-and-networks/Wireless-broadband/WiFi

Read about how CSIRO uses the radio telescopes to track spacecraft
https://publications.csiro.au/rpr/pub?list=SEA&pid=csiro:EP123474&sb=RECENT&expert=false&n=5&rpp=25&page=1&tr=14&q=Spacecraft&dr=all

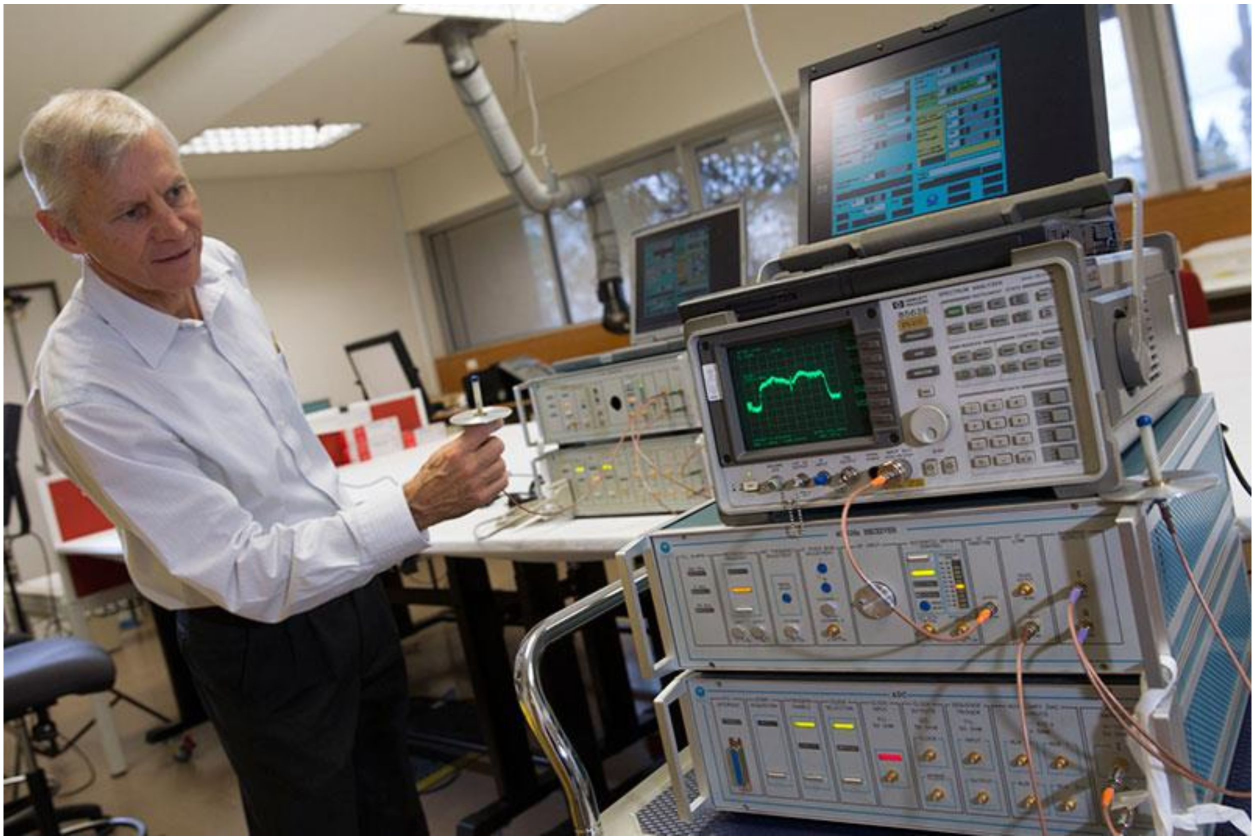
See how CSIRO helped the manufacturing process of spacecraft by creating a new method to apply heat shields
http://www.csiro.au/en/Research/MF/Areas/Chemicals-and-fibres/Materials-for-industry-and-environment/Coatings-and-surfaces/Plasma

See what CSIRO has learned about galaxy formations
2/12/2016 news release “Cool theory on galaxy formation”

Photos

(from CSIRO website) for bottom of left inside page

(from CSIRO news release) for one of pictures on right hand page



(for right hand page) source: http://www.nma.gov.au/collections/highlights/csiro_wlan_collection

(from NASA website) for front cover)

Supplemental Material L

Electrocardiogram Instructor Activity Template

EDUCATION AND OUTREACH
www.csiro.au

Supplemental Materials L

Activity template for ECG activity

CEdO Science Bootcamp

Electrocardiogram

September 2016

Contents

1 Two day overview

Day 1

Time	Activity/Event	Venue	Notes	Presenter roles	Example
9:00am – 9:45am	Setup for the day			Presenters 1, 2, 3 setup	GK Williams Room
9:45am – 10:05am	Doors open Student arrival		Students arrive Need something to entertain those on time or a space for them to congregate in. Science Hangman works surprisingly well.	Presenter 2 sign-in sheet Presenters 1, 3 in room with students	GK Williams Room
10:05am – 10:15am	Behavioural expectations and safety announcement (toilets etc) Get to know you questions		See Educate file path: Public/Community Engagement/BC/BC admin and planning/BC icebreaker activities.pptx	Presenter 2 sign-in sheet Presenters 1, 3 in room with students	
10:15am – 10:50am	Presentation – CSIRO researcher		20min talk, 15min Q&A	Presenters 1,2 supervising Presenter 3 on break 10:45-11:25	
10:50am – 11:20am	Morning tea	Outdoors if weather permitting	Need time to move to first lab tour	Presenter 1, 2 supervising Presenter 3 on break 10:45-11:25	

11:30am – 1:00pm	Lab tours	Either 2x lab tours with 15 students per lab (rotate) approx. 40min per lab (with walking time) OR 2x lab tours with 10 students per lab plus non-lab break with airplane design from 'Thinking Scientifically' or equivalent activity.	All 3 presenters required	GK Williams Room
1:00pm – 1:55pm	Lunch	Students provide their own lunch	Presenter 1 on break (1:10 – 1:50pm) Presenter 2 on break (1:50 – 2:30)	Outdoors if weather permitting
1:55pm – 3:55pm	Acoustics activity: Sound background and xylophone activity, start electrical components	See detailed activity breakdown for details.	Presenter 2 and 3 supervising Presenter 1 setting up open ended activity (2:00pm – 2:15pm)	GK Williams Room/outdoors weather permitting
3:55pm – 4:00pm	Reminders for tomorrow			
4:00pm – 5:00pm	Presenters clean up and re-set for day 2		Presenters 1, 2, 3 pack up	

Day 2

Time	Activity/Event	Venue	Notes	Presenter roles	Example
9:00am – 9:45am	Setup for the day			Presenters 1, 2, 3 setup	GK Williams Room
9:45am – 10:05am	Doors open Student arrival		Students arrive Need something to entertain those on time or a space for them to congregate in. Science Hangman works surprisingly well.	Presenter 2 sign-in sheet Presenters 1, 3 in room with students	GK Williams Room
10:05am – 11:30am	Self-contained laboratory experience Forensics Kit		Special notes exist for BC students. Remember you may need extra explanations at the start based on age of students.	Presenter 2 sign-in sheet Presenters 1, 3 in room with students	
11:30am – 12:00pm	Morning tea	Outdoors if weather permitting	Students provide their own recess		
12:00pm – 12:35am	Presentation – CSIRO researcher		20min talk, 15min Q&A	Presenters 1,2 supervising Presenter 3 on break (12:00 – 12:40)	
12:35am – 1:15pm	CSIRO Quiz		Available in Bootcamp folder.	Presenter 1 on break (12:40 – 1:20pm)	
			Students provide their own lunch		

1:15pm – 2:00pm	Lunch	Outdoors if weather permitting		Presenter 2, 3 supervising	
2:00pm – 3:50pm	Amplifier Activity: Amplifier assembly		See below for activities in detail with timeline		Outdoors if weather permitting
3:50pm – 4:00pm	Wrap up, clean up.		Thanks yous to presenters and students, evaluation forms filled in, items all collected.	Presenter 1 sign-out sheet Presenter 2, 3 supervising	GK Williams Room
4:00pm – 5:00pm	Presenters clean up			Presenters 1, 2, 3 pack up	

2 Hands-On Activity Program Overview

Program name: [Insert super awesome name here]!

Developed by: Morgan Garbett, Nick Pratt, Jake Rivard, Kayla Sica

Date of bootcamp/s: TBD

Brief program outline (max. 2-3 sentences):

Students explore biological signals, electronic circuit design, and digital signal filtering in order to see their own heartbeat in action. They build and test a functioning electrocardiogram, and then utilize it to better understand how doctors see inside the body, and how different activities influence their heartbeat.

~~Students explore circuit design, the use of electronic components in integrated circuits, discover practical and novel uses for this technology, and the versatility of integrated circuits. Students will also learn about waves in several forms, such as sound waves, and their interactions materials.~~

Key concepts/points the program covers

Biosignals

- Your body's communications network
- Electrical and chemical signals
- Building blocks of the nervous system

Medical Monitoring Devices

- What signals do doctors look at?
- How do these machines work?

Building an Electronic Circuit

- Circuit design and circuit diagram
- What different electronic components are and their uses
    - Resistors
    - Capacitors
    - Operational Amplifiers
    - Breadboards

Using Biosignals to Learn about Health

- Measuring heartrate
- Experiment to determine "hardest" exercise

3 Activity Timeline

3.1 Day 1. 120 minutes – Timing is tight, don't talk for too long at the start.

0 – 20	Biosignals Presentation	Give students an overview of biosignals, including information on the nervous system and how they are measured by medical equipment.
20 – 35	Find Your Pulse	Explain to students how to find pulse. Have them figure out how to measure heartrate, and compare resting and active heartrates. Find the average heartrate of the group.
35 – 65	Intro to Electrical Wiring/Schematics	● Overview of electricity and discussion of the different sources ● Discuss the use of electrical components (resistors, capacitors, operational amplifiers) Show the real life thing as well ● Explain how breadboard works, which rows are wired together ● Explain how to read the schematic
55 - 120	Start Build-Your-Own ECG	• Emphasize safety procedures (no laptops plugged into wall, no batteries until after circuit is checked) • Distribute materials including instructions (not including batteries) • Emphasize that students should ask questions when stuck

3.2 Day 2. 110 min

Time (min)	Event	Notes
0 – 5	Review of Material from Day 1	•
5-15	Circuit diagram	• Display circuit for speaker • Explain the tricky bits. Explain the first three steps (where to put components)
15-110	Amplifier Assembly	• Students assemble their amplifier circuits. After approx. 20 minutes ask if anyone wants step by step instructions. All presenters to make sure students know to ask for help (don't just sit there) • Don't forget at end to get students to fill in evaluation forms

4 Risk Assessment ECG

Type of hazard	Description of task or activity	Inherent risk			Existing Controls	Residual Risk		
		High	Medium	Low		High	Medium	Low
Burns from soldering iron	The soldering iron is heated to 315 C		X		• Presenters do the soldering, no students to do the soldering. • Ensure instructors are trained in the use of soldering irons • Ensure all soldering irons work before the activity starts • Soldering to take place prior to Bootcamp • Soldering on the day (if repairs necessary) to take place in a designated spot, away from equipment used by students. • Students warned to stay away from soldering iron.			X
Electrocution	Some equipment (eg computers if plugged into power) powered from a mains power supply, or a circuit powered by a AAA battery.		X		• All electrical equipment to be electrically tested annually • No laptops should be plugged in while working at the table. If a computer must be plugged in, it should be moved to the back of the room and charged before use. • **Computers will ALWAYS be disconnected from power when ECG is connected**			X

				• We will use low voltage (AAA, 1.5V) batteries • Diodes are placed across electrodes in case of current spike from computer battery. The purpose of the diode is to prevent the current of electricity from travelling through the body in the unlikely event that there is a voltage surge. • Electrodes should only be connected to designated locations on the body. If the electrodes are placed in other locations, there is an unlikely chance of more current flowing through the body because there is less resistance to the current when the diode is close together. • The ECG is designed to detect the electric signal in the body. No electric current will be introduced into the body.	
Cuts	Fingers might get cut when cutting wires or trying to plug them into the breadboard.		X	• Using pre-cut wires removes the need for cutting wires • Instructors should supervise students, making sure that they are not being reckless with their wires or other equipment	X
Eye Injury	Students may poke themselves or other students in the eyes with wire ends	X		• Instructors should supervise students, making sure that they are not being reckless with their wires or other equipment • Students will wear safety glasses when working with wire	X

Capacitor Failure	If plugged in incorrectly, some electronic components (capacitors in particular) may overheat and pop	X		• Presenters do not hand out batteries until they have checked a student's circuit • Have an instructor check the circuit before students plug in their batteries (instructors will have detailed instructions on what should be plugged where) • Students can wear safety glasses while assembling their circuits • Warn students of the dangers of electronic components and not to short circuit components • The capacitor is unlikely to cause injury to students unless they are touching it when the battery is connected.	X
Battery Failure	Short circuited batteries are at risk of overheating or chemical leakage	X		• Presenter will check all circuits before batteries are placed in sockets. • Warn students about the dangers of battery acid, and explain how to connect them in series • If a circuit is not functioning, the first step is to detach the battery, so it is only connected for a short period of time. This decreases the risk of overheating or chemical leakage.	X
Trips, falls	Walking around cords or cables		X	• No running • Cords from computers should be positioned on tables/benches so they can't be tripped over. • Cords to be taped down or otherwise secured as required to prevent trip hazard	X

5 Presenter notes/Activity details

5.1 Day 1 Activities: Introduction to Biosignals

Outline

- Introduction to speakers and sounds
  - Go over background information in Powerpoint, introducing things like wavelength and frequency
  - Use a slinky to demonstrate transverse and longitudinal waves. Up and downward movements with slinky are transverse waves. Transverse waves, the particles vibrate at a right angle to the direction of the wave. A longitudinal wave is created with a push of the slinky while it is resting on a surface. The vibrations here are parallel to the direction of the waves. The faster you pump the slinky (so the higher the frequency), the shorter the wavelength is.
  - Test out the dog whistler app and see who can hear the highest frequency sound.

- Make a Water Xylophone
  - Students will be put into groups of 3.
    - The activity is to fill five glass bottles with an amount of water to generate a number musical tone.
    - Best way for frequencies to be recorded is to have two testing rooms. Split students into two groups. Students go with presenter into quiet room. One group at a time records their frequencies while others listen in. Students can also produce their own graph of their frequencies. Most important thing is that students are quiet when testing sounds!
    - Students will record their results for frequency (measured by instructors with the app “Feedback Detector” on their mobile device/tablet) and water level to graph them as a group on the board (or as excel on screen). Once the students have collected enough data points, they will see the relationship between the water level and frequency generated.
    - The students can then try playing simple songs with each other after finishing their data collection.
- Materials needed:
  - Water
  - Large Jugs x 10 (or similar receptacle)
  - Measuring cylinders (10ml – 500ml suitable for use)
  - Glass bottles x50 (each group needs five bottles all the same type) Remove labels from bottles prior to use.
  - Spoons (metal) x10

- Sheets of graph paper x10 (one for each team)
- Rulers x10 (one per team)
- Pencils x10 (one for each team)
- Metal Slinky x3

Process

- Do a demonstration of the xylophone activity and how to record.
- For more information on any of the topics to discuss, please refer to the background info.

Sound

- Discuss the connections to CSIRO provided on the slides. Be sure to emphasize their connection to sound and waves.
- Ask what sound is, and then give them the definitions on the slide after they have given their answers. Talk about sound being a wave.
- Added blank slide with "how are sounds made" Ask the students how sounds are made. Discuss that sound is the result of vibrations in a medium.
- Ask if someone knows what a continuous sound comes from. Answer: objects vibrating back and forth like drumming. Pass around tuning forks and show the students the vibrations causing sound.

Waves

- Ask students what a wave is and what defines a wave.
- Ask the students what the different types of waves are. Then describe both longitudinal and transverse waves. Use a slinky to demonstrate transverse and longitudinal waves. Up and downward movements with slinky are transverse waves. Transverse waves, the particles vibrate at a right angle to the direction of the wave. A longitudinal wave is created with a push of the slinky while it is resting on a surface. The vibrations here are parallel to the direction of the waves. The faster you pump the slinky (so the higher the frequency), the shorter the wavelength is.
- Then go over frequency, amplitude and wavelength.
- Do a quick activity with a dog whistle app. The app "Dog Whistler - Your Free Dog Whistle" should be downloaded on the presenter's phone. After explaining that the human range of hearing is between 20 Hz and 20,000 Hz, test the hearing range of the students. Begin at 20 Hz and slowly move to 20,000Hz. Have the student raise their hand when they can start to hear sound and then put down their hand when they cannot hear the tone any longer. See which students have the best hearing.
- Briefly go over sounds through different mediums, sound travels fastest though solids since the molecules are most tightly packed together, then liquids, then gases.

Xylophone Activity (remember safety in hitting bottles)

- This activity will use the application 'Spectrum Analyser' by keuwlsoft on Android, and 'Feedback Detector' by Sonoma wireless on IOS. You can also use 'SpectrumView' by Oxford Wave Research Ltd and 'n-Track Tuner' by n-Track.
- When testing frequencies, hit the bottles in the same spot a few times in a row to try and see where the frequency on the application is bouncing around.

- Explain the xylophone competition and break the students into different teams than before.
- Explain that the students need to construct a graph to show the correlation between water level and frequency produced. (use paper and give them rules to draw straight lines and plot proper points)
- Once they have created a complete graph, discuss relationship between frequency and water level. See if there are any anomalies. Draw a trend line on the graph.
- To finish this section of the activity play a simple tune for the students on a series of bottles you have prepared earlier.

CSIRO Connections

- Anechoic Chamber
  - Successful calibration of noise measuring equipment to international standards requires an anechoic chamber
  - An anechoic chamber prevents the reflection of sound waves by completely absorbing them
  - Prolonged solitude in an anechoic chamber can cause disorientation in humans because it is so quiet
- Research Vessel Investigator
  - This is a new vessel supporting Australia's atmospheric, oceanographic, biological, and geosciences research
  - The Investigator maps the ocean floor using sonar waves
  - Analyses weather patterns with a meteorological radar system
  - The Investigator is tasked with deep sea oceanography, mapping and studying the geology of Australia's marine estate, and to learn more about Australia's weather patterns and large ocean processes
- Wildlife Sound Archive
  - CSIRO's wildlife sound archive is part of the Australian National Wildlife Collection (ANWC)
  - Library consists of over 60000 recordings, making it one of the largest libraries of its kind in the world
  - This library is currently being turned into a digital database
  - The database is steadily being made available online through the Atlas of Living Australia

Electricity and where it comes from as per powerpoint slides

<u>What is Electricity?</u>

- Go over the slide and mention that today will focus on current electricity
- Briefly explain what a circuit is

<u>Real Life Context</u>

- Ask students about the daily use of electricity and to give some examples of appliances.
- After they have identified the 4 given in the slide, ask them whether they can think of any difference between them. Size/power needed/different source are acceptable answers.
- Use this to go into the two different sources of electricity.

Different Sources of Electricity

- Present with the help of background info.

Basic Concepts of Electricity

- Present with the help of background info.

Intro to Circuitry

- Tell students that scientists won't get the help that CAN (not will) be provided to them today.
- They don't have a picture of the working circuit, neither descriptions nor instructions on how to connect components.
- Instead, they get a very complicated diagram like the one shown and have to understand how to read the schematic and assemble the circuit.
- That is why we need to know the basic components and how to connect them.

Breadboards and circuits

- Introduce basic concepts of electricity
- Introduce students to electronic components
    - Discuss with students different electrical components

    - What a breadboard is, how it works
    - Create a very simple circuit (demonstration) – battery, breadboard, red LED which lights up. (this will blow if lit up for more than a couple of seconds so get components connected on breadboard then just touch battery to connectors (don't plug in) to show LED lit up. Remove quickly.

Create a circuit in series (Students to perform) – battery, breadboard, resistor, red LED which lights up. Again, students shouldn't plug the battery actually in just touch it to the terminals.
If time, students can create a small circuit according to your hand-drawn circuit diagram on a whiteboard.

5.2 Day 2 Activities: Electronics, circuitry, and circuit assembly

Outline

- Students work as individuals to assemble their circuits

    - Students can choose to assist each other if they want to work together or they finish early
- Have extra components on hand so students have extras in case they mess up
    - Extra components should have been ordered
    - Encourage students to discover means of improving their circuits on their own after they leave Bootcamp
    - Possible Improvements: first one should be taking the 100 nF capacitor from 7 on the op amp to ground out of the circuit and putting a 100 uF capacitor from pin 1 to pin 8 on the op amp. This increases the gain on the op amp, increasing the output voltage, increasing the loudness of their music. Their speakers will not be able to handle this gain though.
- Students have 100 minutes to construct their circuits
- Students are able to design different circuit configurations
- If circuit is incomplete, an instructor should help them finish if the student is running out of time

- Materials needed:
    - Breadboard x30
    - 10 kohm potentiometer x30
    - 47 nF capacitor x90 (this includes extras)
    - 100 nF capacitor x45 (this includes extras)
    - 100uF capacitor x45 (this includes extras)
    - 220 uF capacitor x45 (this includes extras)
    - 10 ohm resistor x30
    - LM386 Op Amp x30
    - 9V battery x30
    - Jumper wire kits x5 (to be shared by the students)
    - Soldering Iron x1 (to be on standby if someone needs something soldered again)
    - Soldering wire (to be on standby with the soldering iron)
    - Speaker x 30
    - 3.5mm audio jack x30
    - Handouts/Instructions x30

Process

Demonstration

- Part begins by demonstrating the final audio amplifier circuit working.

Basic Components

- Go thru components

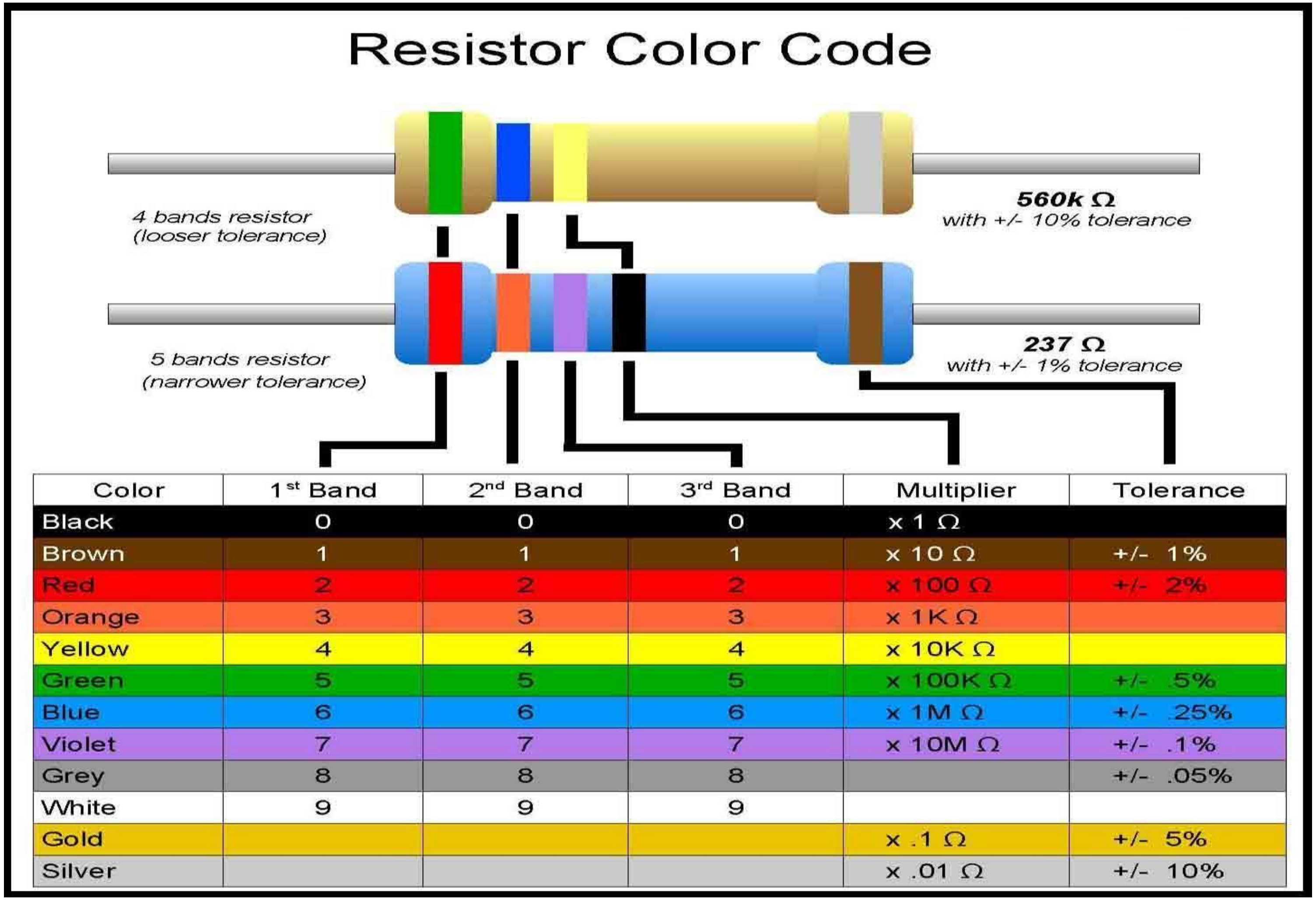
Making your circuit

- Go over the notes included on the page with the diagram
- Make sure students remember which battery terminal is which
- Make sure you explain what a ground rail is.
- Make sure you tell students which is the positive and which is the negative (ground) terminal on the audio jack
- The speaker isn't polarised and either lead can go to either spot.

- You'll need to remove any phone cases being tested before using them as the audio jack wont slot in sufficiently.
- If students have a perfectly good looking amplifier and aren't getting any sound replace first the op-amp, then the capacitors, then the audio jack, then the speaker, then every other component unti it works.
- If students are using an ground connected wire as a ground and it is also plugged into the op-amp this is perfectly correct however sometimes it seems to screw up the sound amplification so create a separate ground wire connection and keep it separate from the op-amp pin rows.
- Don't hand out batteries until you have checked their circuit at least once.

5.3 More detailed background information with references

Resistor Coding Diagram



Color	1st Band	2nd Band	3rd Band	Multiplier	Tolerance
Black	0	0	0	x 1 Ω	
Brown	1	1	1	x 10 Ω	+/- 1%
Red	2	2	2	x 100 Ω	+/- 2%
Orange	3	3	3	x 1K Ω	
Yellow	4	4	4	x 10K Ω	
Green	5	5	5	x 100K Ω	+/- .5%
Blue	6	6	6	x 1M Ω	+/- .25%
Violet	7	7	7	x 10M Ω	+/- .1%
Grey	8	8	8		+/- .05%
White	9	9	9		
Gold				x .1 Ω	+/- 5%
Silver				x .01 Ω	+/- 10%

Source: http://nearbus.net/wiki/images/7/7d/Resistor_color_codes.jpghttp://nearbus.net/wiki/images/7/7d/Resistor_color_codes.jpg

http://nearbus.net/wiki/images/7/7d/Resistor_color_codes.jpg

Resistor

Source: https://en.wikipedia.org/wiki/Resistorhttps://en.wikipedia.org/wiki/Resistor

Integrated Circuit

Source: https://en.wikipedia.org/wiki/Integrated_circuithttps://en.wikipedia.org/wiki/Integrated_circuit

Operational Amplifier

Source: https://en.wikipedia.org/wiki/Operational_amplifierhttps://en.wikipedia.org/wiki/Operational_amplifier

Capacitor

Source: https://en.wikipedia.org/wiki/Capacitorhttps://en.wikipedia.org/wiki/Capacitor

Speaker

Source: https://en.wikipedia.org/wiki/Loudspeakerhttps://en.wikipedia.org/wiki/Loudspeaker

https://en.wikipedia.org/wiki/Loudspeaker

5.4 CSIRO Stories

UltraBattery: http://csiro.au/en/Research/EF/Areas/Energy-storage/UltraBatteryhttp://csiro.au/en/Research/EF/Areas/Energy-storage/UltraBattery

Wearable Technology: http://csiro.au/en/Research/Technology/Wearable-technologyhttp://csiro.au/en/Research/Technology/Wearable-technology

Guardian Angel: http://csiro.au/en/Research/DPF/Areas/Autonomous-systems/Guardian?featured=1A2262E5940C42108ED550A5ED4C51A0http://csiro.au/en/Research/DPF/Areas/Autonomous-systems/Guardian?featured=1A2262E5940C42108ED550A5ED4C51A0

Wildlife Sound Archive: http://www.csiro.au/en/Research/Collections/ANWC/About-ANWC/Our-wildlife-sound-archivehttp://www.csiro.au/en/Research/Collections/ANWC/About-ANWC/Our-wildlife-sound-archive

MagSonic: http://www.csiro.au/en/Research/MRF/Areas/Community-and-environment/Responsible-resource-development/MagSonichttp://www.csiro.au/en/Research/MRF/Areas/Community-and-environment/Responsible-resource-development/MagSonic

Research Vessel Investigator: https://www.cmar.csiro.au/research/seamounts/documents/fr199907sum.pdfhttps://www.cmar.csiro.au/research/seamounts/documents/fr199907sum.pdf

Electronics Projects

Electronics Projects: Beginner

Source: http://www.instructables.com/id/Beginners-Electronics-Projects/http://www.instructables.com/id/Beginners-Electronics-Projects/

Electronics Projects: Advanced

Source: http://www.edutek.ltd.uk/Projects.htmlhttp://www.edutek.ltd.uk/Projects.html

http://www.edutek.ltd.uk/Projects.html

Visualizing Sound

Chladni Plate

https://en.wikipedia.org/wiki/Ernst_Chladnihttps://en.wikipedia.org/wiki/Ernst_Chladni

http://www.instructables.com/id/How-to-make-a-Chladi-plate-vibrating-membrane/http://www.instructables.com/id/How-to-make-a-Chladi-plate-vibrating-membrane/

Ruben’s Tube

https://en.wikipedia.org/wiki/Rubens%27_tubehttps://en.wikipedia.org/wiki/Rubens%27_tube

Practical Applications of Sound

Sonar

https://en.wikipedia.org/wiki/Sonarhttps://en.wikipedia.org/wiki/Sonar

Radar

https://en.wikipedia.org/wiki/Radarhttps://en.wikipedia.org/wiki/Radar

Ultrasound

https://en.wikipedia.org/wiki/Ultrasoundhttps://en.wikipedia.org/wiki/Ultrasound

Alternating Electrical Current

https://en.wikipedia.org/wiki/Alternating_currenthttps://en.wikipedia.org/wiki/Alternating_current

6 Equipment List

Item	Quantity	Supplier	Notes (eg order takes 6 weeks to arrive)	Unit cost	Qty
Speaker	3	eBay	Pack of 10, takes about a month to ship from China CS HAS	$6.97	
Solderless Breadboard	6	eBay	Come in packs of 5 CS HAS	$5.44	
10 kohm potentiometer	30	Jaycar	CS HAS	$0.30	
47 nF capacitor	90	Jaycar	One extra per student. CS HAS	$0.21	
LM 386 Op Amp	1	eBay	Pack of 50, only need 30, takes up to a month to ship from China. CS HAS	$3.60	
100 nF capacitor	45	Jaycar	From Jaycar, need 30, ordered 60 so students have extras CS HAS	$0.30	
100 uF capacitor	45	Jaycar	From Jaycar, need 30, ordered 60 so students have extras CS HAS	$0.29	

220 uF capacitor	45	Jaycar	From Jaycar, need 30, ordered 60 so students have extras CS HAS	$0.28
9 V battery	30	Office Max	Check for leftovers from previous Bootcamps	$1.42
10 ohm resistor	4	Jaycar	4 packs of 8 from Jaycar CS HAS	$0.55
3.5mm Audio Jack	3	dx.com	May take several weeks to ship, sold in packs of 10 CS HAS	$4.64
1.75mm PLA 600g	3	3D Printing Superstore	From 3D printing superstore. CS to print 3D parts required	$32.00
Red LED lights	1	eBay	From eBay, ships in 1-2 weeks TO PURCHASE	$8.88
9V Battery Clip	30	Jaycar	TO PURCHASE	$0.30
Jumper Wire Kit	5	eBay	Comes with wires of varying lengths, some wires may be too long to use CS HAS	$3.98
Soldering Wire	1	Storeroom	Check you have some	$1.36
~~Tape~~	~~1~~	~~Woolworths~~	~~Come in spools, sometimes several per package~~	~~$3.00~~
Soldering Iron	1	Storeroom	Already have on site, may need to ship to other sites	$0.00

Flashforge Dreamer	1	Storeroom	CS will print out for you all required 3D printed parts	$0.00
Bottles	50	Storeroom	Student groups need a set of 5 identical bottles Presenters to source	$0.00
Metal Spoons	20	Storeroom/Kitchen	Should have spoons available on site, 2 spoons per group	$0.00
Scissors	10	Storeroom	Already on site	$0.00
Rulers	10	Storeroom	Already on site	$0.00
Slinky	1	toystore	May need to purchase first	$3.00
iPhone/iPad/Android phone	2/3	Storeroom/Personal	Needed for frequency measurement during xylophone	$0.00
Feedback Detector	2/3	iPhone/iPad personal/CSIRO	App needed for measuring frequency during xylophone. Created by Final Mix, Inc., available in the app store 'Spectrum Analyser' or Frequency Counter by keuwlsoft by keuwlsoft on Android. The iOS app is far better than the Android options.	$0.00
The app "Dog Whistler - Your Free Dog Whistle		Iphone/ipad	It's a bit of fun and the kids will be surprised at what they can hear and what other people can't hear.	$0.00
Video camera (may work on laptop to	1	Storeroom		$0.00

view components more closely)		
	Sub total	$446.57
	+ 10% for unexpected costs	
	TOTAL COST	$491.23

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w www.csiro.au

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FOR FURTHER INFORMATION

Insert Flagship/Business Unit name
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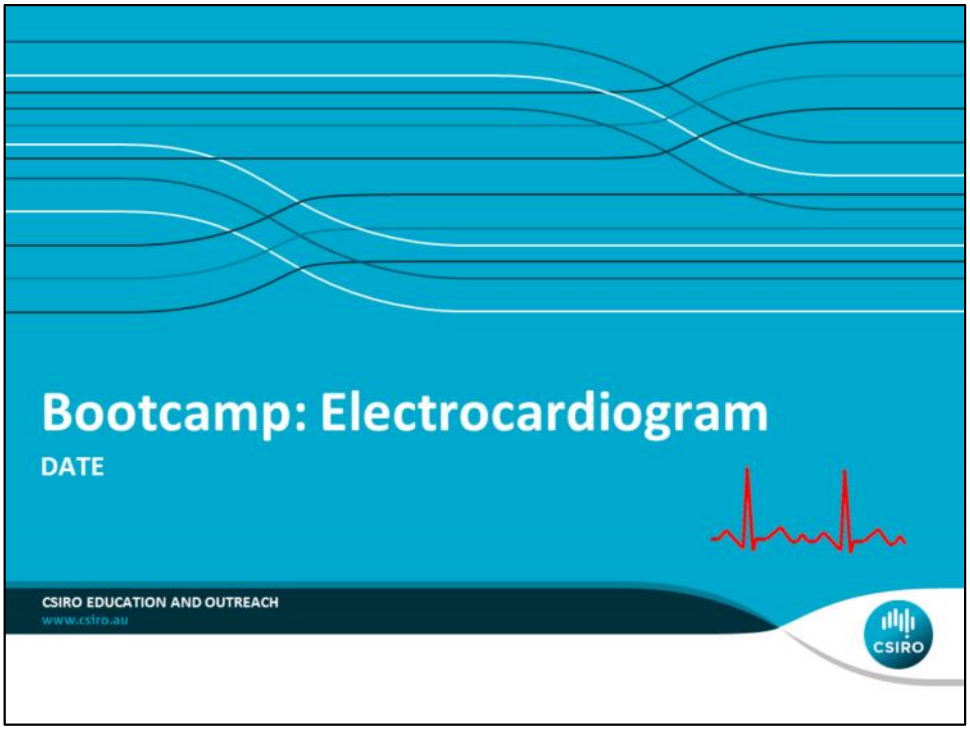
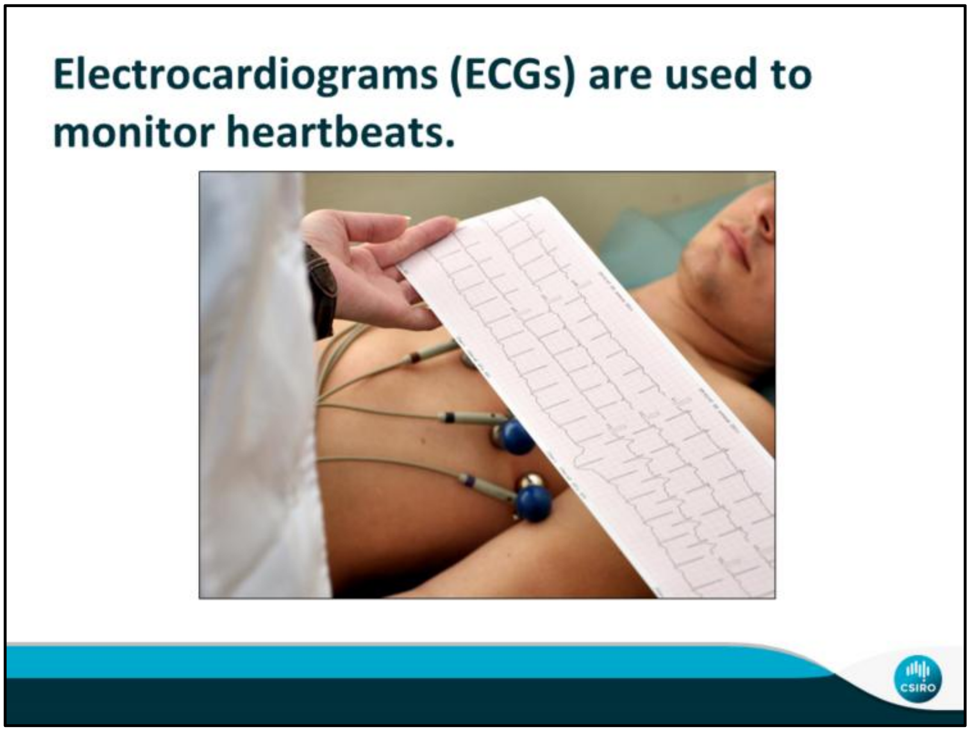
Supplemental Material M

Presentations for ECG Activity


Bootcamp: Electrocardiogram
DATE
CSIRO EDUCATION AND OUTREACH
www.csiro.au
CSIRO

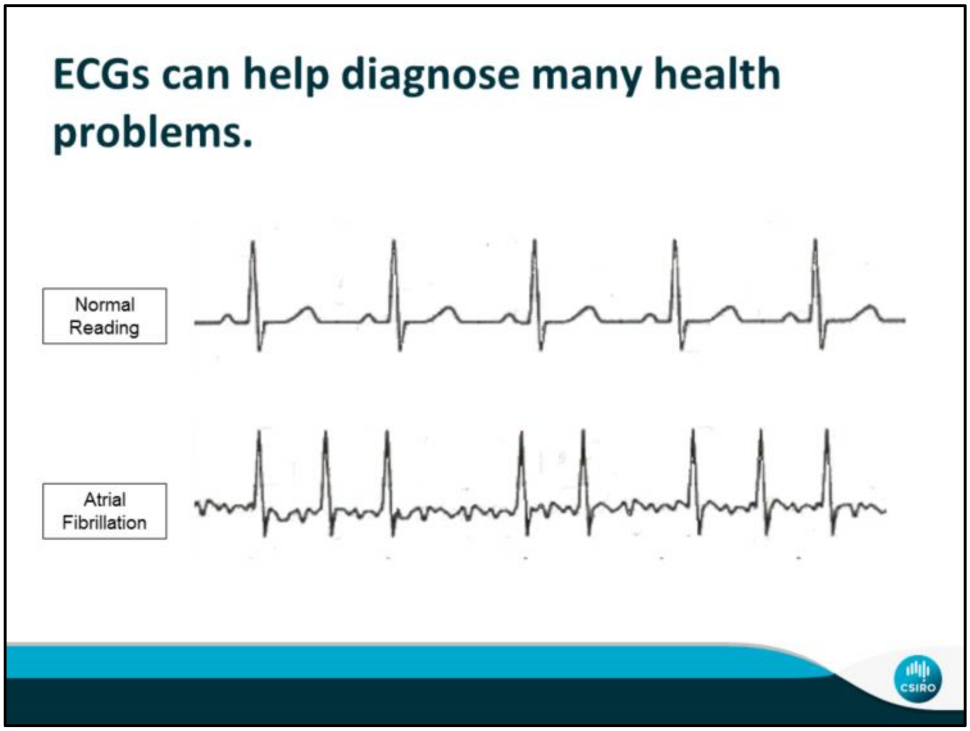
Doctors look at biosignals to learn more about health issues.

A signal is anything that carries information.
A biosignal is a signal produced by a living being, like your body.
Usually, biosignals are used by your body to allow different parts to communicate.
By observing them they can be used to diagnose certain diseases and conditions.



- One type of biosignal a doctor looks at is an electrocardiogram
  - This is a reading of the electrical signals of a human heart
  - When the different valves of the heart contract, large electrical pulses travel through your body
  - These signals can be picked up on the skin outside your body, where they are much smaller
- ECGs detect the heart signal by amplifying tiny electrical differences on the surface of your skin. It then displays these differences on a screen or sheet of paper.

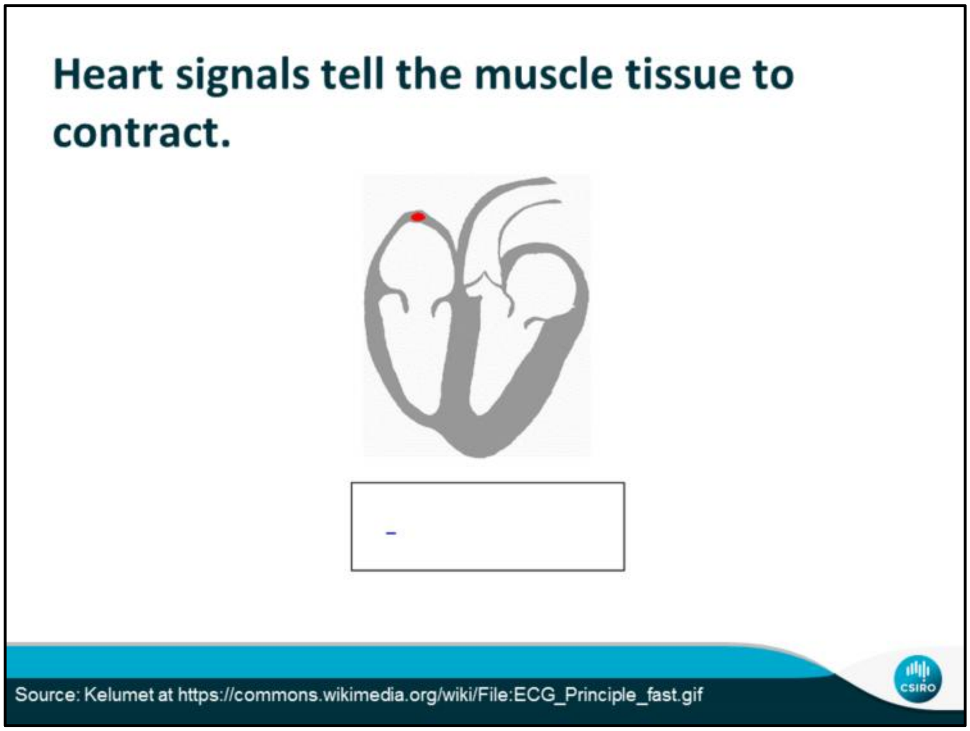
Sources
https://www.betterhealth.vic.gov.au/health/conditionsandtreatments/ecg-test



- ECGs are used to diagnose heart diseases
    - **Atrial Fibrillation (the bottom readout) - when the top chamber of the heart flutters instead of beating (fully closing)**
    - Recent Heart Attack - when someone had a heart attack
    - Enlarged Heart - when the heart is under constant strain and becomes enlarged
    - Abnormal Heart Rhythm - when the heartbeat is inconsistent
    - Blocked Artery - when blood cannot flow through part of the heart due to a clog

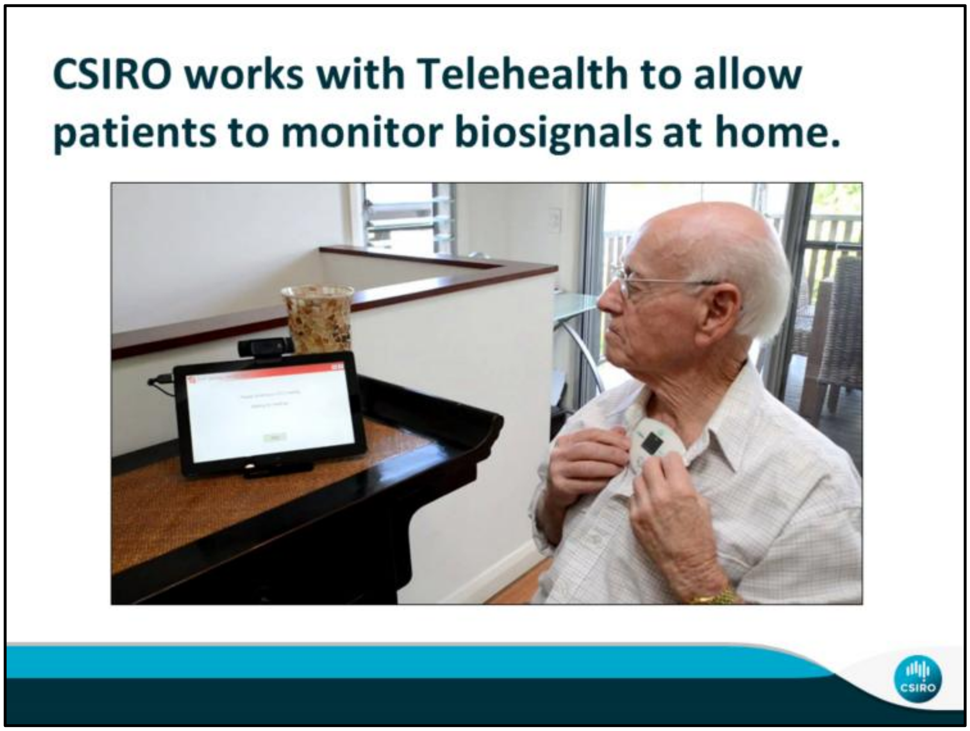
Label

Sources
https://www.betterhealth.vic.gov.au/health/conditionsandtreatments/eeg-test
http://www.webmd.com/heart-disease/guide/heart-disease-symptoms-types



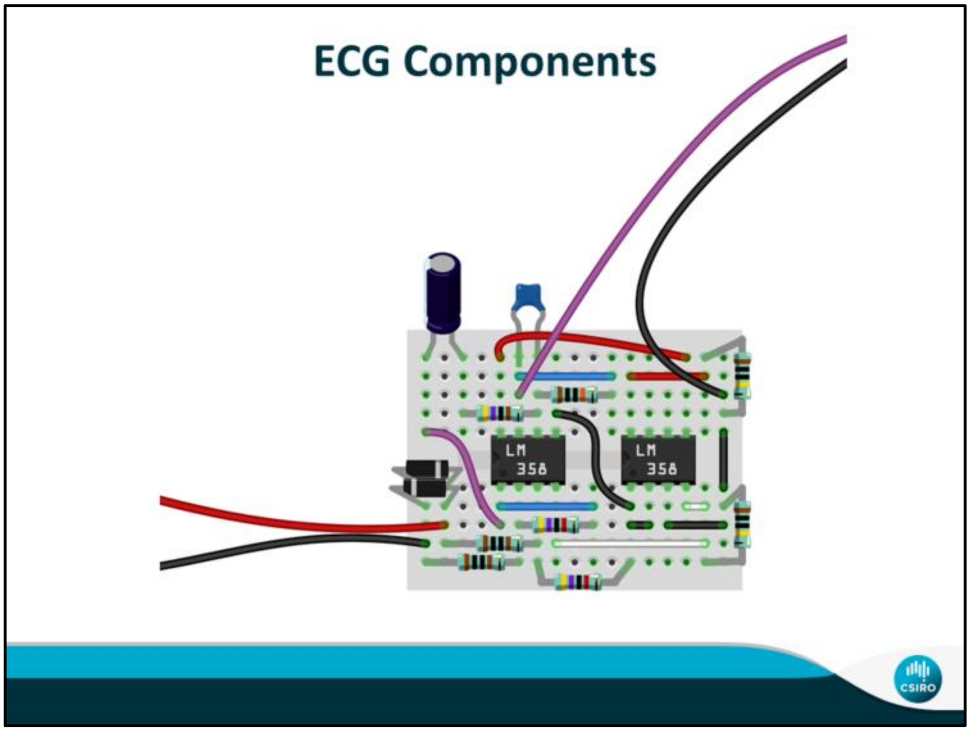
- The Sinoatrial Node sends out the electrical signal to tell the heart when to contract
- each part of the heart knows which part of the signal means for it to contract
- They contract in sequence to pump blood through the body.

Sources
https://www.boundless.com/physiology/textbooks/boundless-anatomy-and-physiology-textbook/cardiovascular-system-the-heart-18/cardiac-muscle-tissue-174/mechanism-and-contraction-events-of-cardiac-muscle-fibers-874-8546/

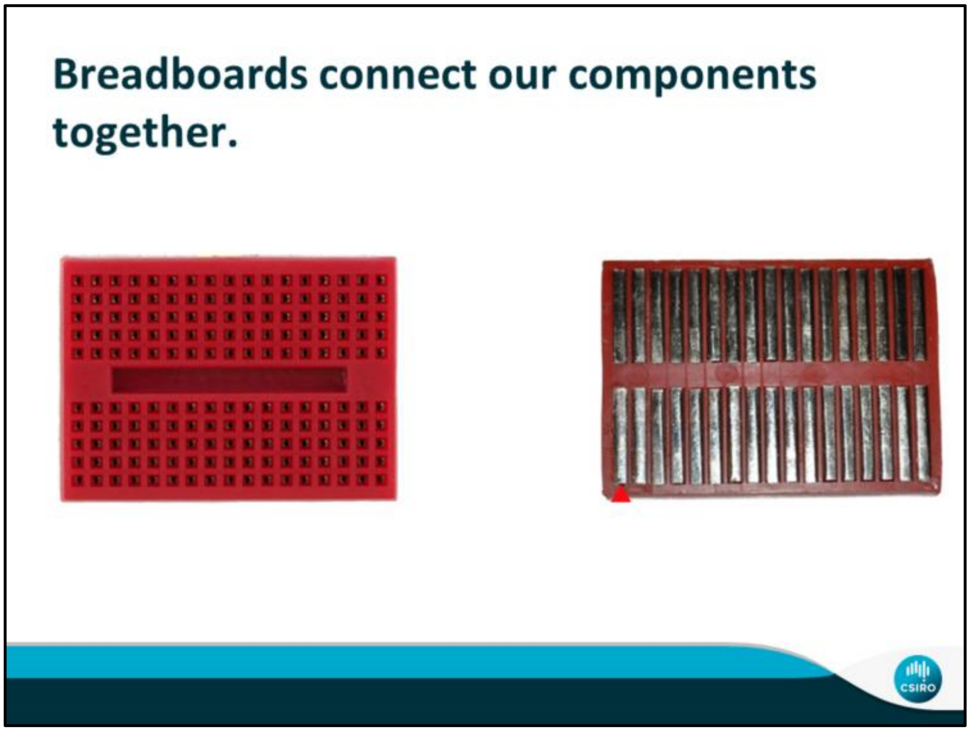


- A lot of people who have heart diseases also have other health problems
- This means they visit the hospital often, which is very expensive
- CSIRO and Telehealth are working together to create a home monitoring system partly made up of ECGs
- This would save money as well as make monitoring their health easier

Sources
http://www.csiro.au/en/Research/BF/Areas/Digital-health/Improving-access/Home-monitoring

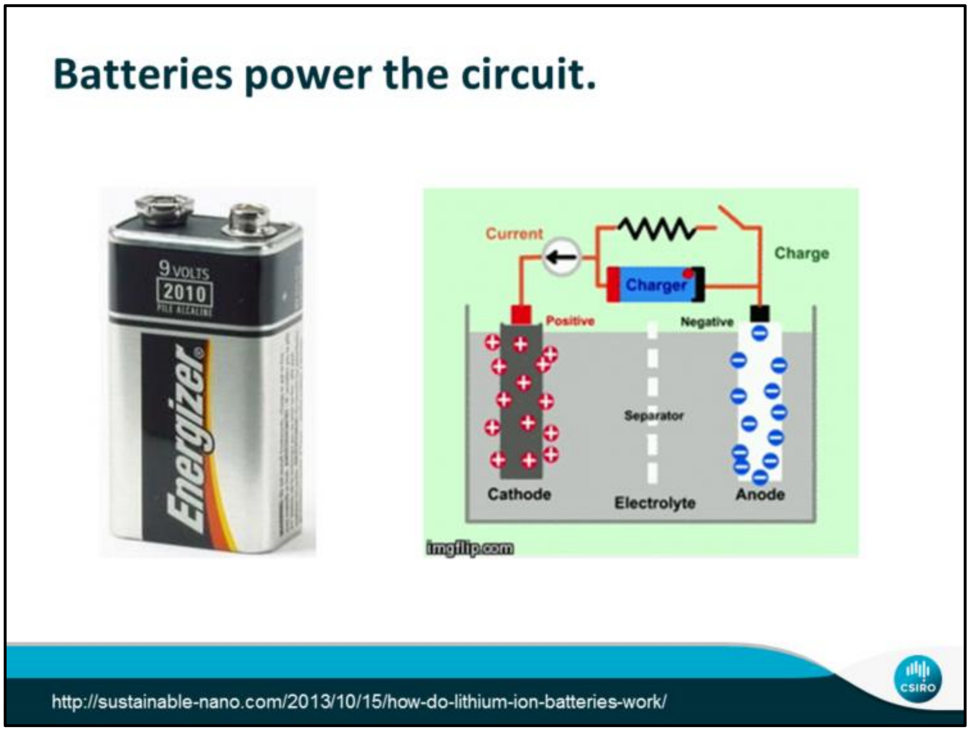


- Here are all the electrical components you will use to build your ecg



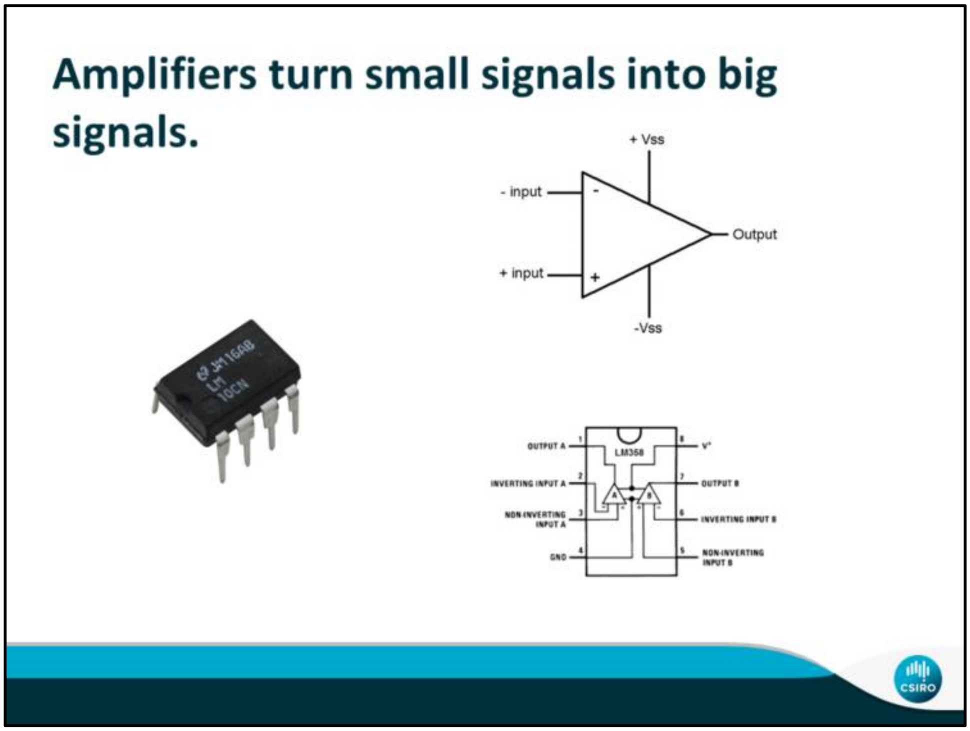
- A breadboard is what all of the wires are plugged into.
- Provides the foundation for your circuit
- The holes are connected by metal inside

Sources
https://learn.sparkfun.com/tutorials/how-to-use-a-breadboard



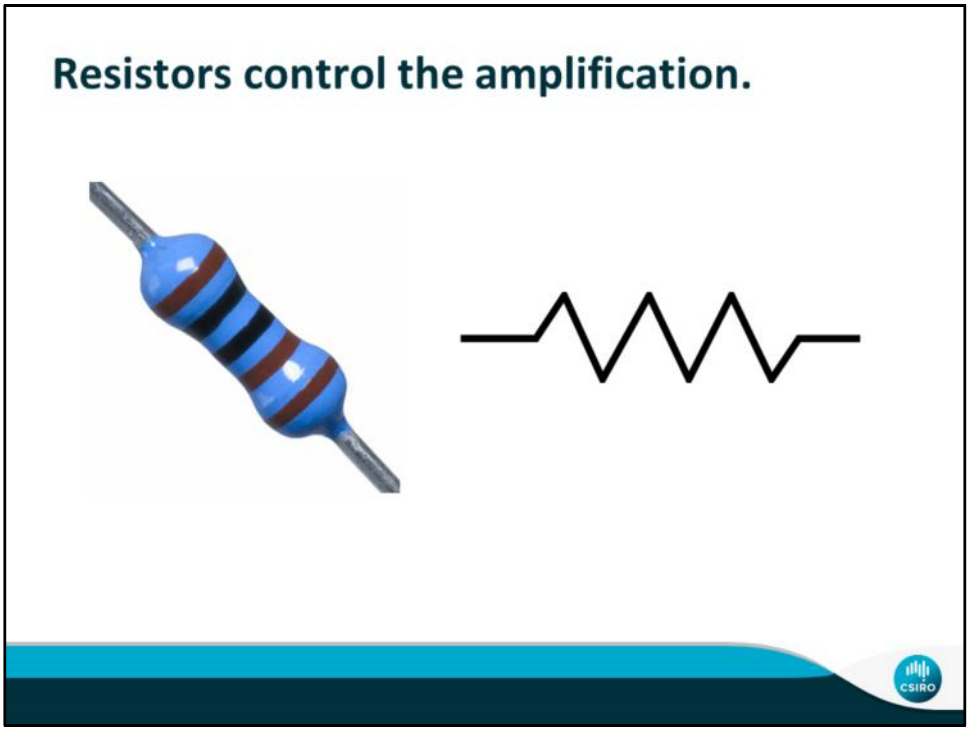
- Generates electrical voltage

Source
http://engineering.mit.edu/ask/how-does-battery-work



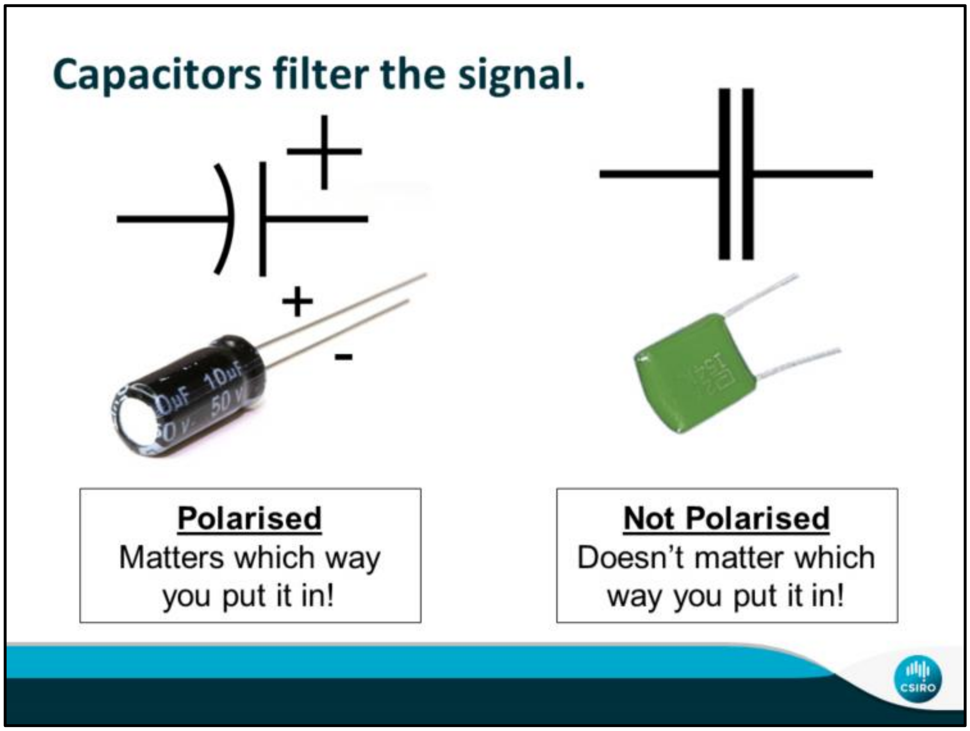
- An operational amplifier is used to “amplify” the signal.
- A heartbeat only changes the voltage across your body by about 1 mV.
- In order to be seen by your computer, this voltage must be raised to about 1V.
- An op-amp integrated circuit (the thing that looks like an 8 legged bug) actually has two amplifiers in it.
- How much the amplifier boosts the signal, or the “gain” can be set with the input and feedback resistors.

Source
http://chrisgammell.com/how-does-an-op-amp-work-part-1/



- Is a wire with a colorful bulb in the middle
- Made up of a material that is not a good conductor
- controls the gain from the amplifiers (how much stronger the signal gets)

Source
https://learn.sparkfun.com/tutorials/resistors



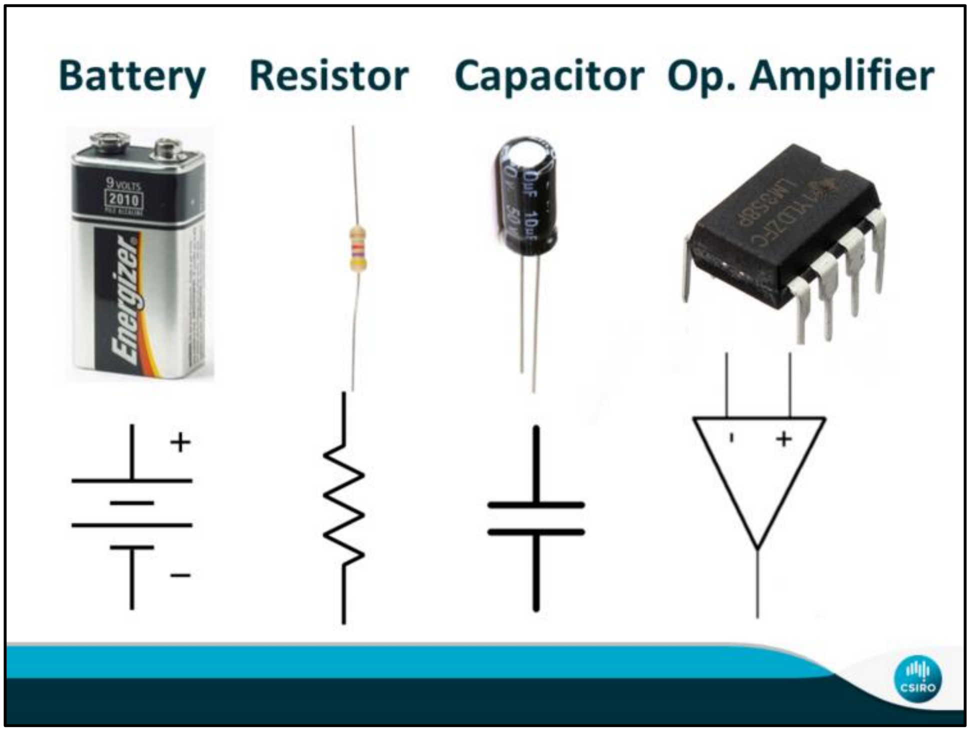
- A capacitor stores electric charge
- Polarised capacitor only works with the current flowing in a certain direction through it
- Used to filter the signal

Source
https://learn.sparkfun.com/tutorials/capacitors

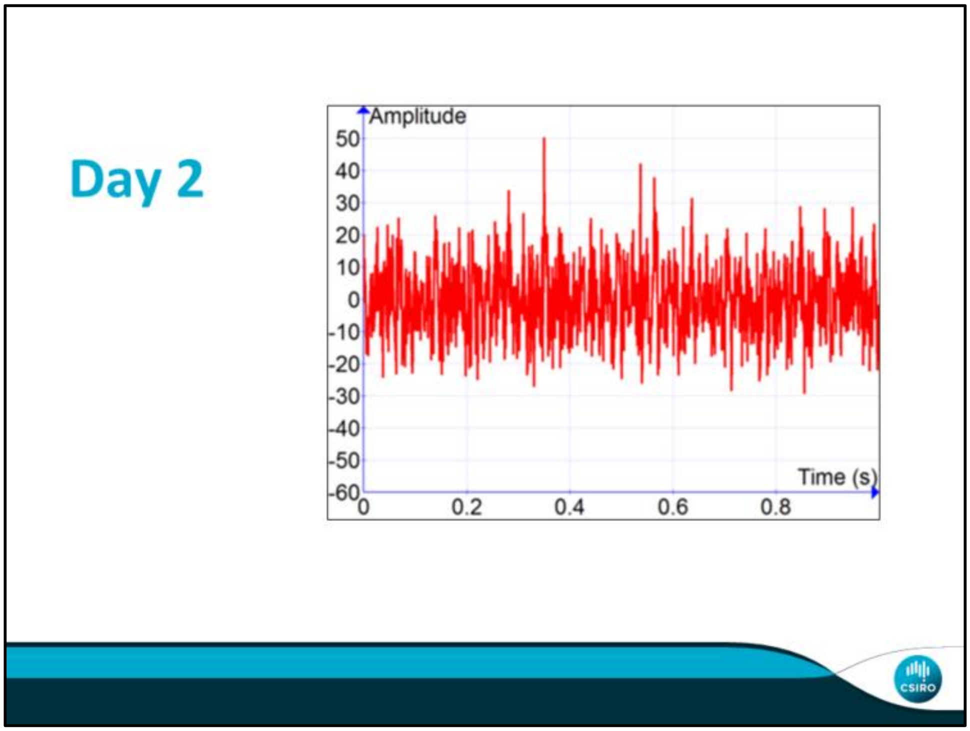
Slide 12

CS [5]1 Might be nice to point out which end of the actual capacity picture is the positive end.
Carly Siebentritt, 12/8/2016

CS [6]1 I also changed the word polarized to polarised for Aussies
Carly Siebentritt, 12/8/2016



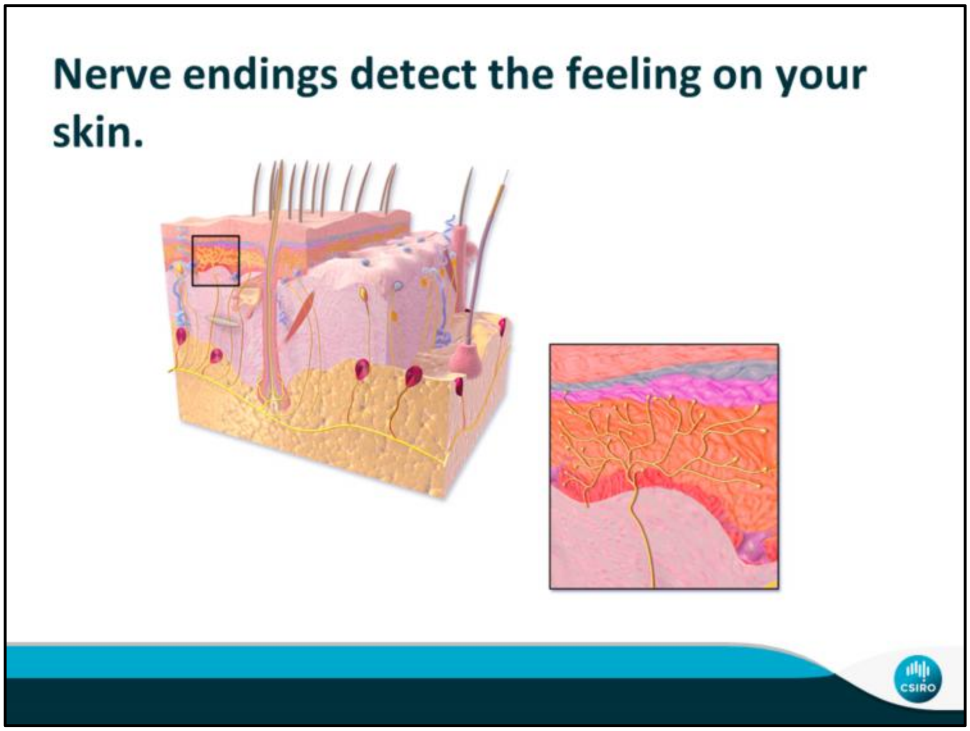
Leave up during the construction of the ECG



- Today we are going to talk about other biosignals and methods of picking them up
- Picture of a heartbeat

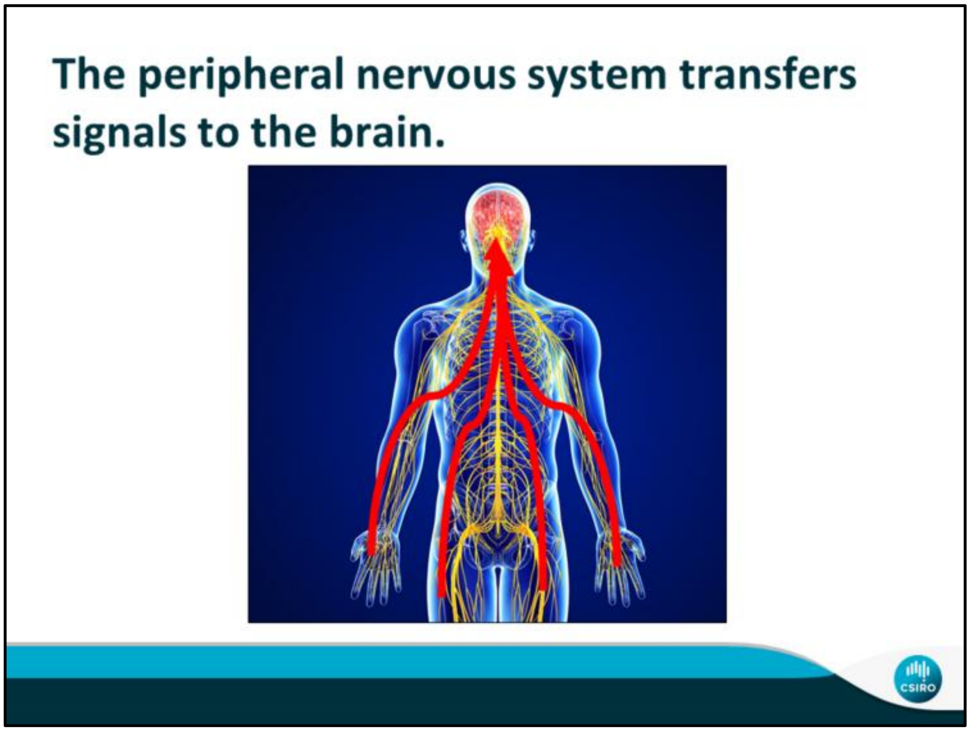
- In order to understand a little more about biosignals, let’s think about when we dive into cold water

Source
http://www.freefoodphotos.com/imagelibrary/cooking/hot_electric_hob.jpg



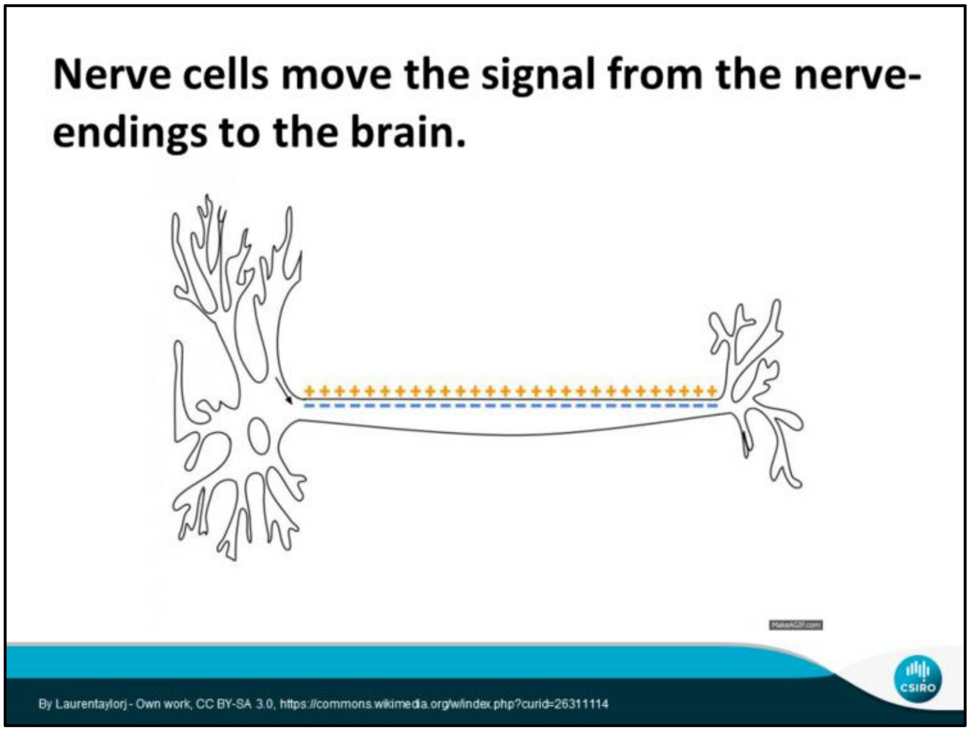
- The nerve endings on your fingertips sense the cold
  - They are the parts of your body that pick up temperature and among other senses
  - You don’t immediately feel the cold though, because the nerves don’t transmit data instantaneously

Source
https://en.wikipedia.org/wiki/Free_nerve_ending



- Signals come from the nervous system, which is how it your body communicates with itself
- sends signals from one part of your body to the other
- It is made up of nerves
- Whenever you move or feel its because your nerves sent a signal to your muscles or your brain

Sources
http://data61.csiro.au/sitecore/content/CSIRO/Website/Research/MF/Areas/Biomedical/Health-and-wellbeing/Brain-imaging-software?sc_lang=en



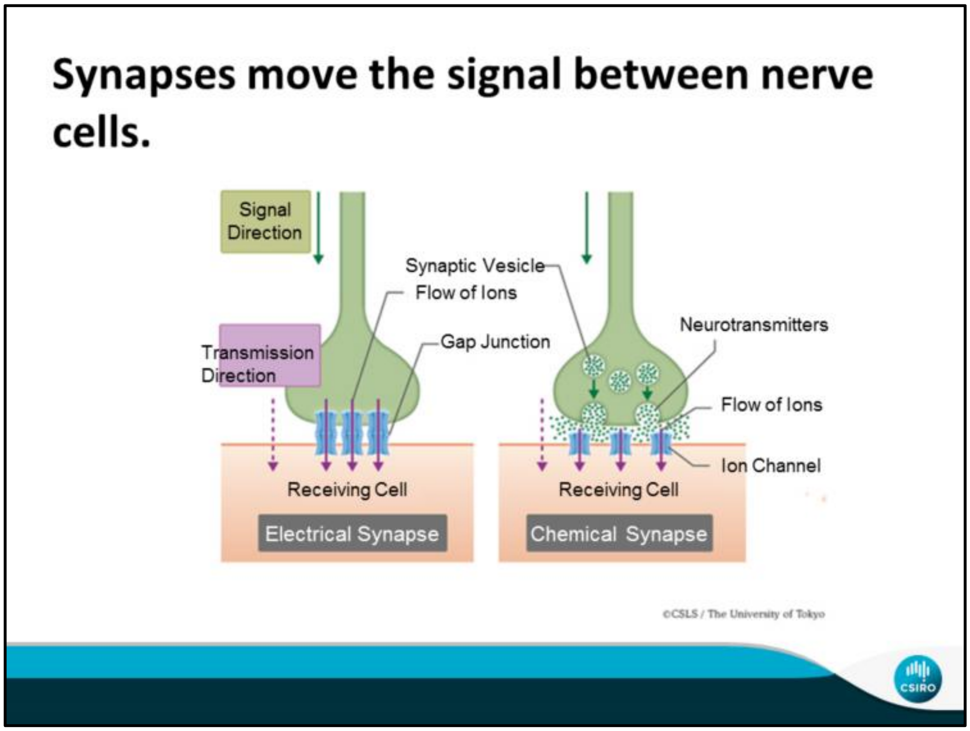
- Nerves use electrical signals to communicate
- However, they are terrible conductors of electricity
- This does not allow for a constant flow of electricity
- Nerve cells use charged particles, or ions, to move a quick burst of electricity, which is called an Action Potential
- Sodium ions are normally on the outside of your nerve cell and potassium ions on the inside, but as the signal reaches the nerves, channels open and then close rapidly, allowing the ions to switch quickly where they are
- this triggers the next channel to open and as the area with the potassium ions on the outside flows down the nerve so does the action potential

Sources
http://www.ptdirect.com/training-design/anatomy-and-physiology/nerves-neurons-2013-anatomy-and-function

Slide 18

CS [7]1 The whole Nerve cell/synapse explanation bits are a bit messy and difficult to understand. Perhaps add some extra lines or re-phrase

Carly Siebentritt, 12/8/2016

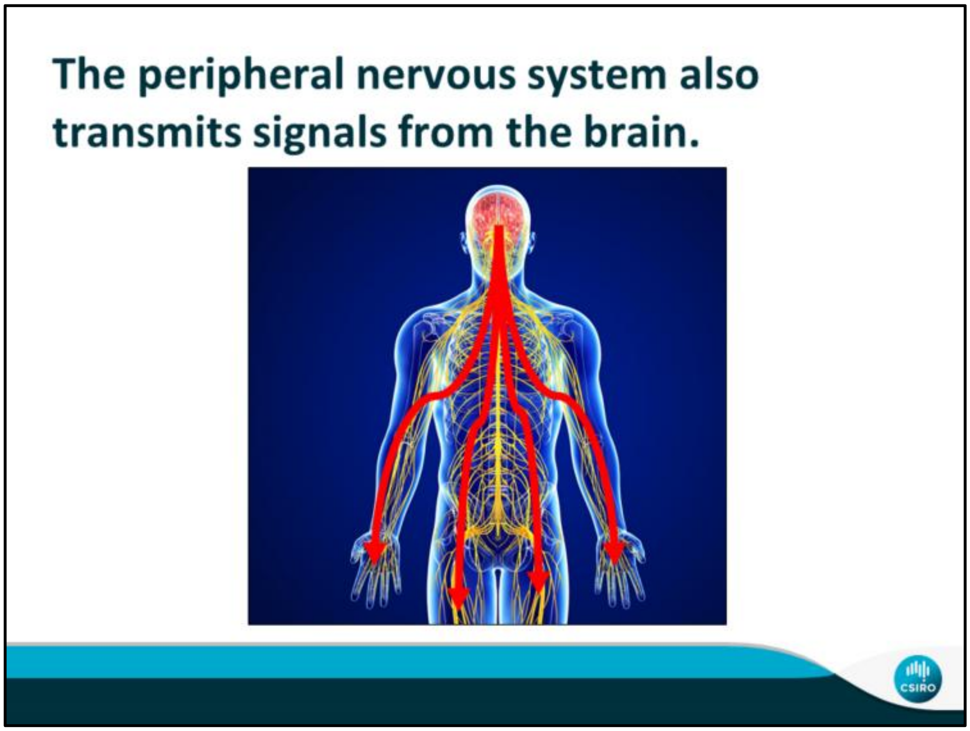


- This signal moves from cell to cell through either an electrical or chemical synapse
- Electrical synapses are much faster, but can only be triggered for a short time as the current passes through
- This happens since the positive ions from the action potential are allowed to flow though the gap junction
- This created the same charge difference in the next cell, triggering the release of the potassium ions and starting the action potential over again
- Chemical synapses are slower but can be triggered for longer since it takes longer for the chemicals to dissipate
- When the action potential reaches the end of the nerve cell the ions that make up the moving action potential trigger the release of calcium ions
- These calcium ions enter the end of the nerve and allow pockets of neurotransmitters that are inside to be released from the cell
- The neurotransmitters then diffuse across the gap between nerve cells into the beginning of the next one

- This binding allows the ions in the cell to switch to the outside, and the action potential process begins again

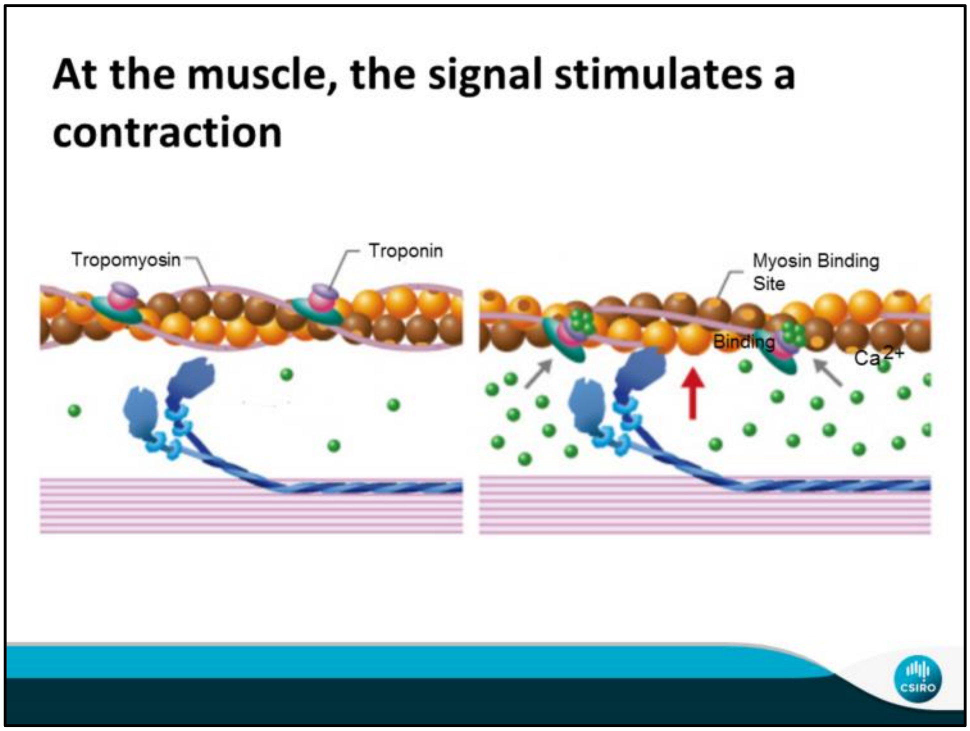
Sources

Electrical synapse - https://www.ncbi.nlm.nih.gov/books/NBK11164/
Chemical synapse - https://www.boundless.com/biology/textbooks/boundless-biology-textbook/the-nervous-system-35/how-neurons-communicate-200/synaptic-transmission-763-11996/



- Your peripheral nervous system also transfers signals from your brain to your muscles.
- Every time you move a muscle, your peripheral nervous system is at work
- Because it knows it’s cold, your brain will want to move muscles to get you out of there

Sources
http://data61.csiro.au/sitecore/content/CSIRO/Website/Research/MF/Areas/Biomedical/Health-and-wellbeing/Brain-imaging-software?sc_lang=en



- When a nerve is telling a muscle to contract, the electrical signal at the end of the nerve triggers a release of calcium ions
- These ions trigger the release of a chemical that binds to a part of the muscle that prevents the myosin from binding to the muscle
- This makes the “shield” move out of the way and allows the myosin to bind to the muscle
- The myosin then curls, pulling the muscle

Sources
http://legacy.owensboro.kctcs.edu/gcaplan/anat/notes/api%20notes%20j%20%20muscle%20contraction.htm

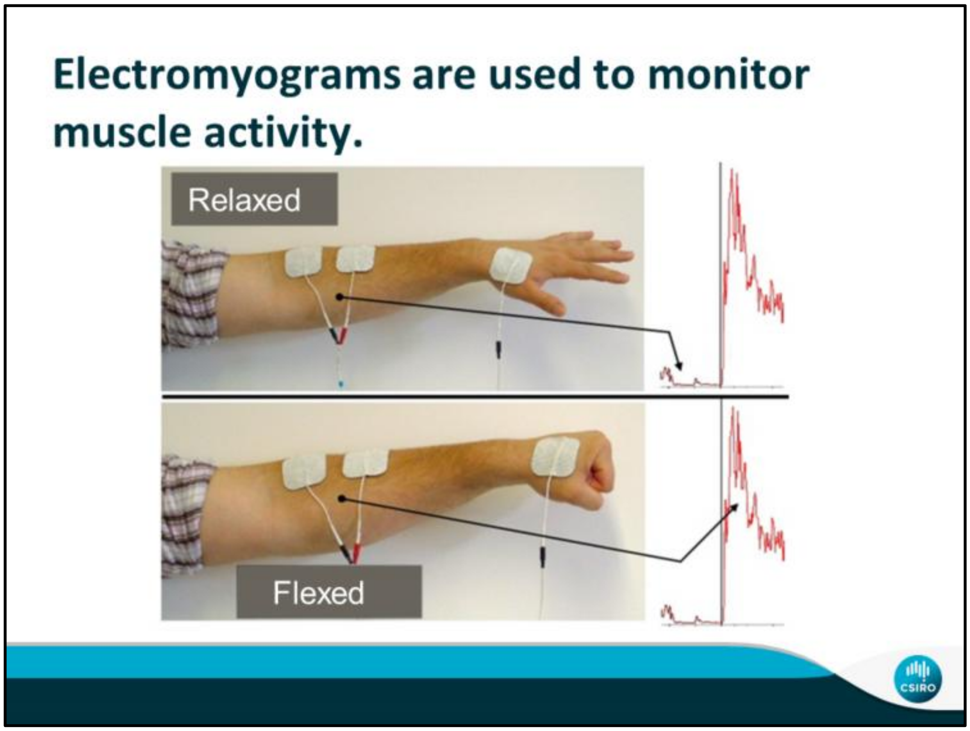
Slide 21

CS1 What Shield? does the shield have a name on the diagram?

Carly Siebentritt, 12/8/2016

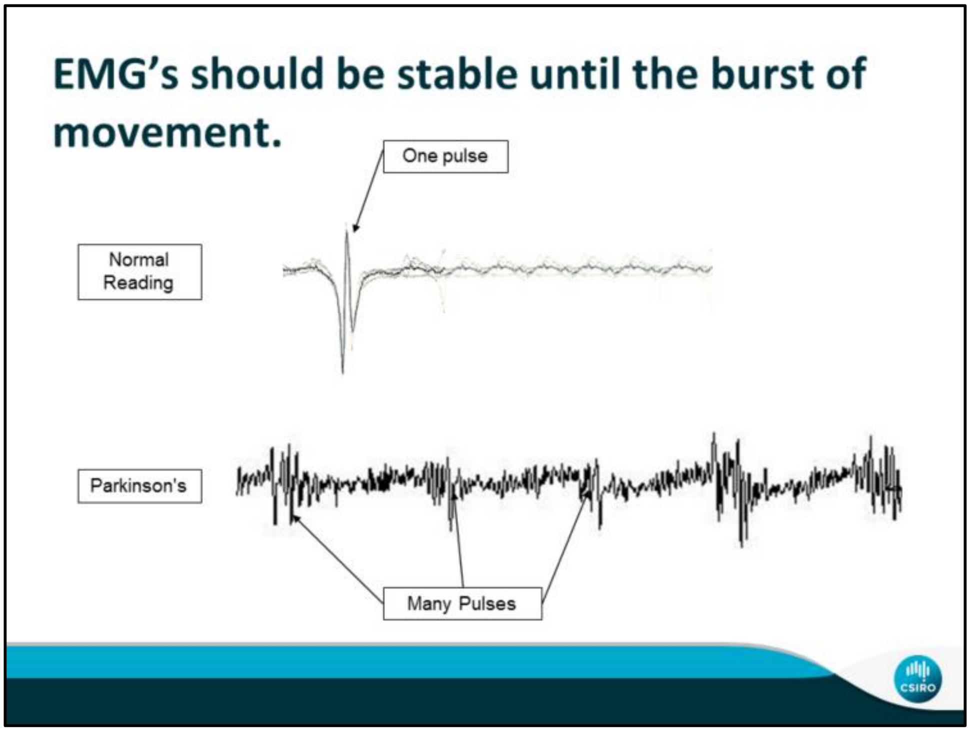
- In order to understand a little more about biosignals, let’s think about when we dive into cold water

Source
http://www.freefoodphotos.com/imagelibrary/cooking/hot_electric_hob.jpg



- An EMG detects the electrical signal telling muscles to contract
    - This is similar to how an ECG detects electrical signals telling your heart muscles to contract
    - Can use multiple probes around the body
- it has a sensor on either side of the muscle and when the muscle contracts it amplifiers the electrical signal
- EMG signals are harder to identify than ECG signals because they are irregular
    - They only appear for a short time while the muscle is moving or being flexed
- Doctors also use EMGs to diagnose diseases and conditions

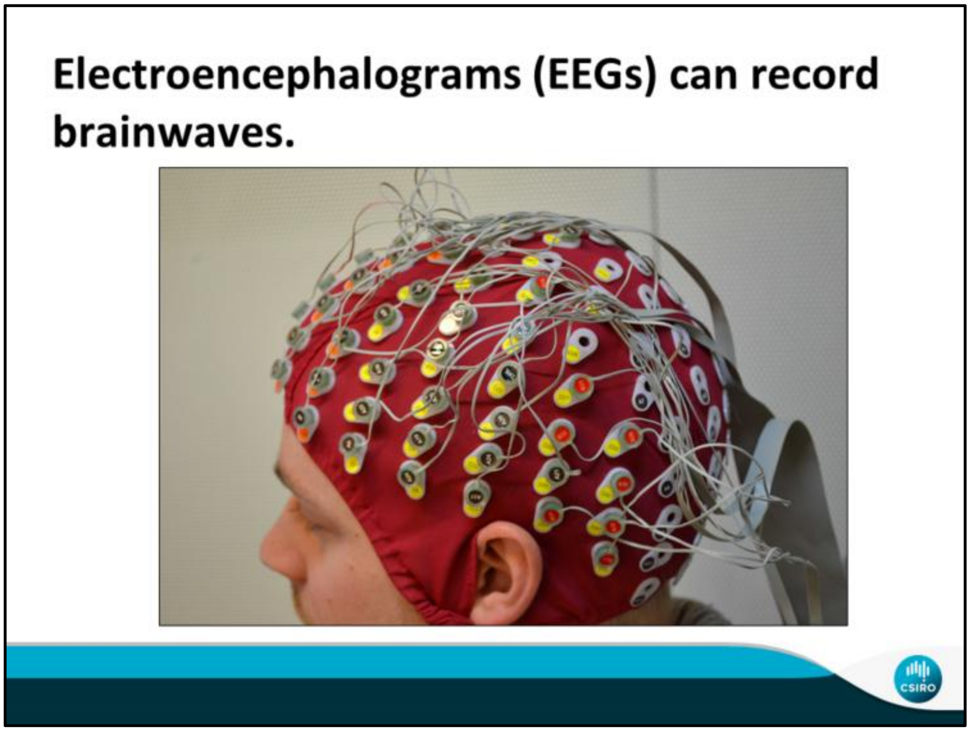
http://legacy.owensboro.kctcs.edu/gcaplan/anat/notes/api%20notes%20j%20%20muscle%20contraction.htm



- Since the current can only flow in short bursts, a readout from an EMG should be a fairly stable line and then a sudden, short burst of waves
- The top is a normal EMG reading, notice how the line is stable before the signal
- The bottom is an example of a readout from someone with Parkinson's
- A symptom of Parkinson's is that the muscles keep moving, so instead of a line it is always wavy as the muscle in constantly moving
- Muscular Dystrophy - a condition that causes someone's muscles to slowly but progressively weaken
- Carpal Tunnel - when the muscle around the wrist becomes swollen and constricts nerves
- Motor Neuron Disease - When the nerves that control movement die

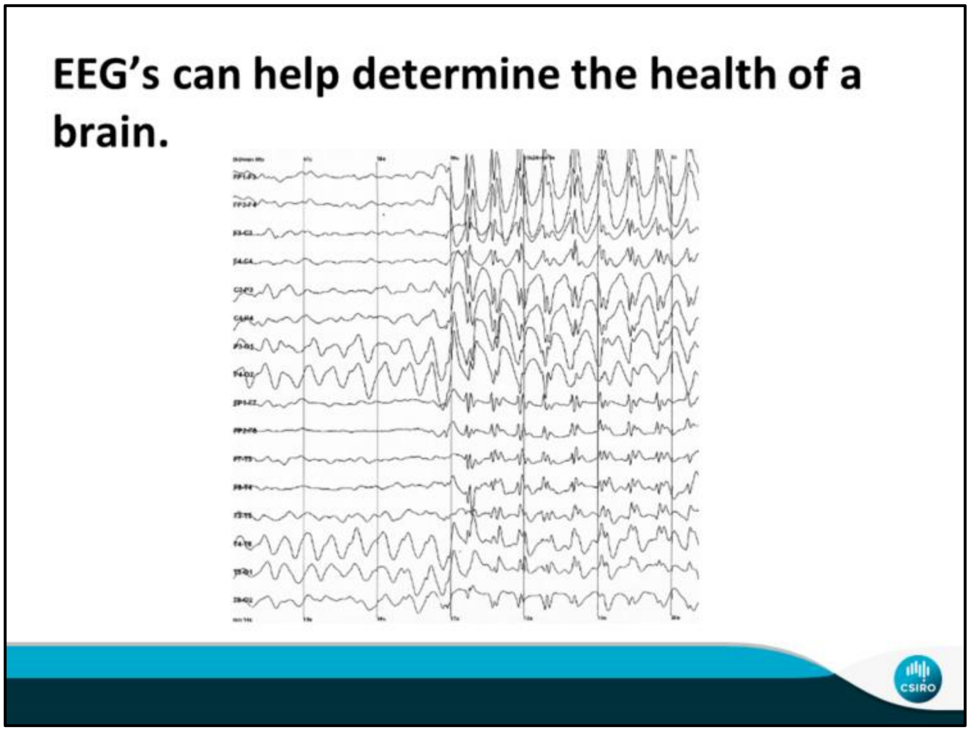
Slide 24

CS [2]1 Should i see images from other diseases on the screen as i flick through or does it just show Parkinsons?
Carly Siebentritt, 12/8/2016



- You’ve seen how these signals can be picked up from the heart and other muscles
- They also work for the nerves in your brain
- EEGs measure the electrical current on the surface of the brain
- When you think small magnetic fields are created by the neurons in your brain as information moves around. An EEG picks up these magnetic fields and allows doctors to identify different events, like sleeping and seizures.

Sources
http://www.csiro.au/en/Research/MF/Areas/Biomedical/Health-and-wellbeing/Brain-imaging-software
https://www.psychologie.uzh.ch/dam/jcr:ffffffff-ee02-4002-0000-00003ef7165c/EEG-03.jpg



- Connection to CSIRO: they are working on software to use the 2D surface map of electrical activity to create a 3D model of the brain's electrical activity LINK: http://data61.csiro.au/sitecore/content/CSIRO/Website/Research/MF/Areas/Biomedical/Health-and-wellbeing/Brain-imaging-software?sc_lang=en
- This would allow doctors to use EEGs to more accurately diagnose conditions that may only affect a certain part of the brain such as a stroke
- This is an example of a readout from a EEG of someone with Epilepsy - it is normal on the left and the right is the patient having an epileptic seizure
- Alzheimer's - brain cells that control reasoning and memory die
- Narcolepsy - When the brain cannot control sleep-wake cycles and experience extreme tiredness or fall asleep inconveniently
- Stroke - when a blood clot cuts off blood flow to a part of the brain and the cells die
- Brain death- when the brain has suffered so much damage that it can no longer make the body breathe

Sources
https://www.betterhealth.vic.gov.au/health/conditionsandtreatments/eeg-test
http://www.webmd.com/brain/brain-diseases#1

Questions?

www.csiro.au

CSIRO

Slide 27

CS [3]1 Two CSIRO logos?
Carly Siebentritt, 12/8/2016

CS [8]1 Maybe steal the Question slide from the Astronomy ppt?
Carly Siebentritt, 12/8/2016

Supplemental Materials N

ECG Activity Handouts

Supplemental Materials N

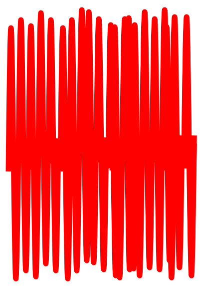
ECG Activity handouts

Step-by-Step Instructions for Simple ECG Construction

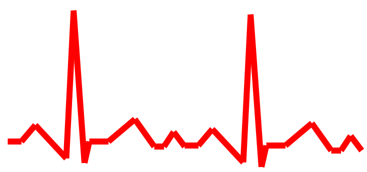
An electrocardiogram is a machine that records or displays a person's heartbeat. Essentially, it senses the electrical impulses that your bodies uses to make your heart beat, and shows them on a monitor or, in this case, a computer.

By the time it reaches your arms, the electrical signal of your heart is very small (approximately 1mV), so it must be amplified many times to be seen by most computers (to approximately 1V). Because many electrical signals exist within the human body, the ECG must also filter out those signals.

Raw signal, too small to detect.

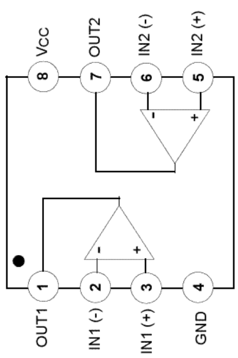


Signal after amplification, with plenty of noise.

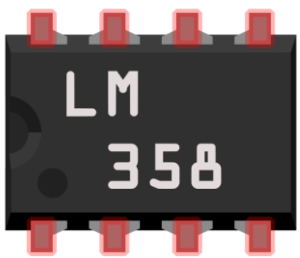


Amplified signal after filtering

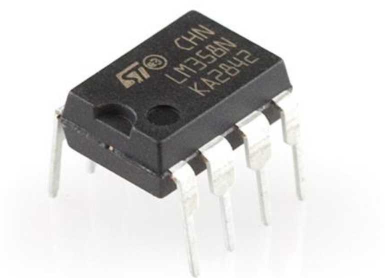
This activity uses three amplifiers to achieve this goal. Each LM358 chip conveniently has two amplifiers, three of which will be used for the electrocardiogram. The pin numbers are shown in the figure below. Starting at the half moon shape on the edge of the chip, the pins are numbered 1 through 8 moving counterclockwise. The first amplifier doesn't actually do any amplifying but helps create the right power sources in the circuit. The second two amplifiers both amplify the circuit.



Symbolic view of LM358



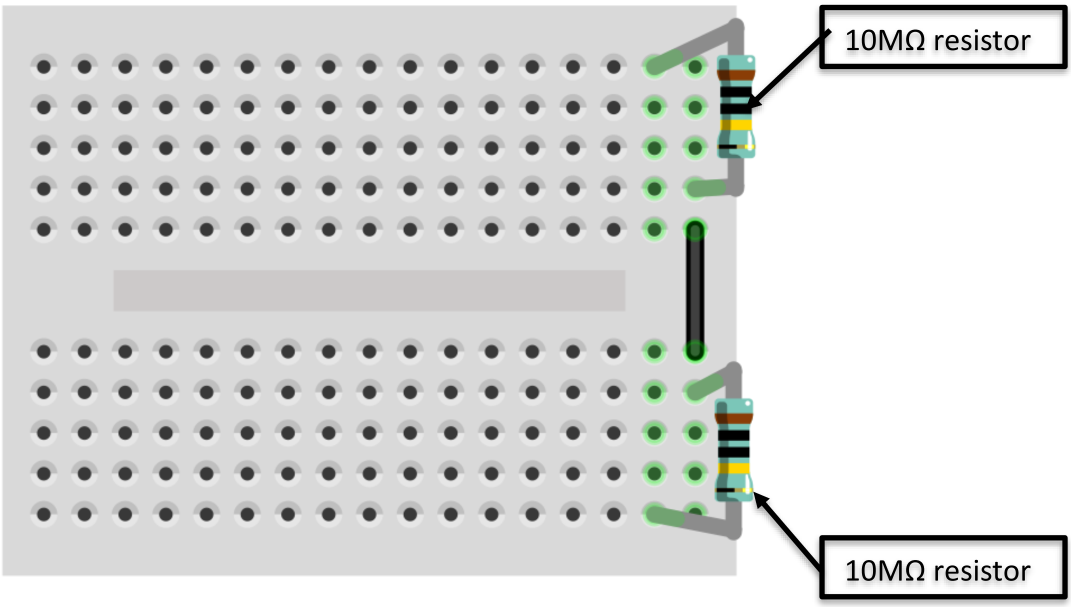
Breadboard view of LM358



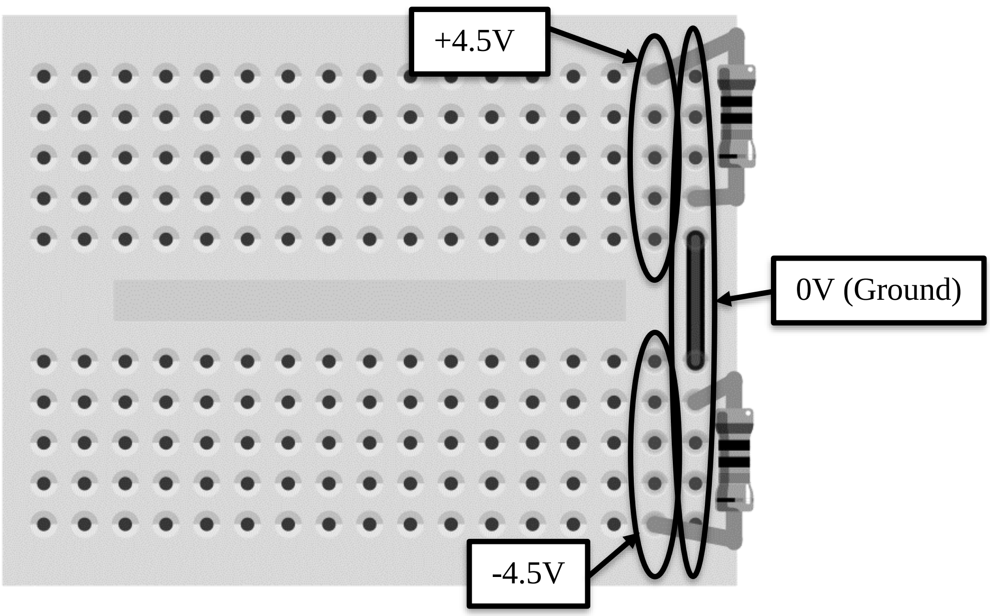
Actual view of LM358

Step 1: We'll start out by building the circuit to power your ECG. In order to have an output signal that is both positive and negative, we need to have both positive, and negative voltages (as well as a ground reference (0V). In order to do this, we'll divide the voltage over two 10MΩ resistors—known as a voltage divider. The terminals of the battery will be connected to the two ends of the divider. We'll use the middle of the divider as our "ground" or 0V mark. This makes the two ends of the divider +4.5V and -4.5V.

Components:

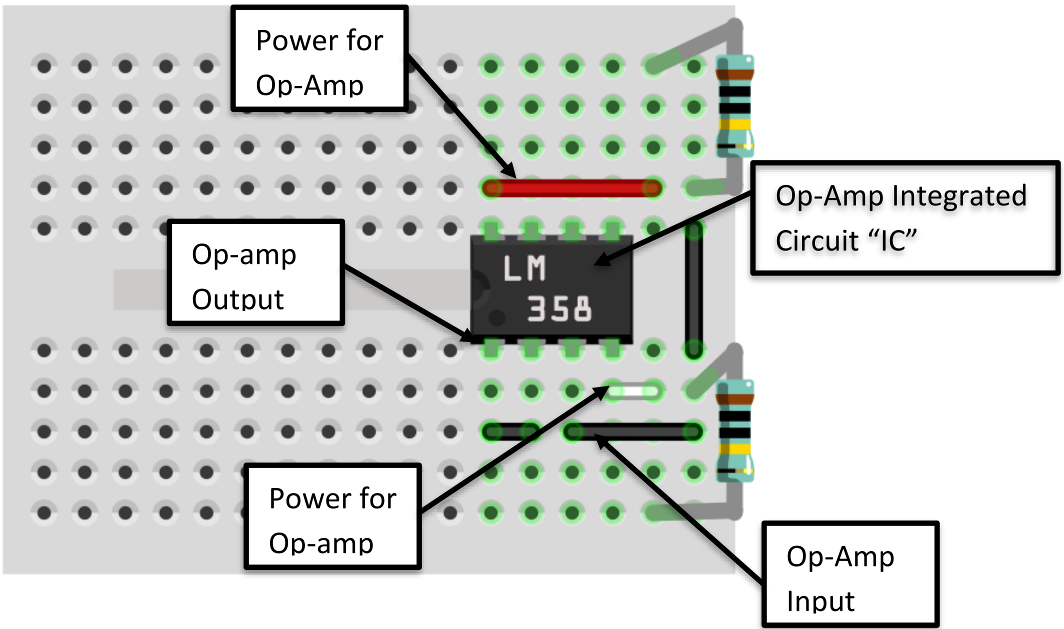


Voltages:

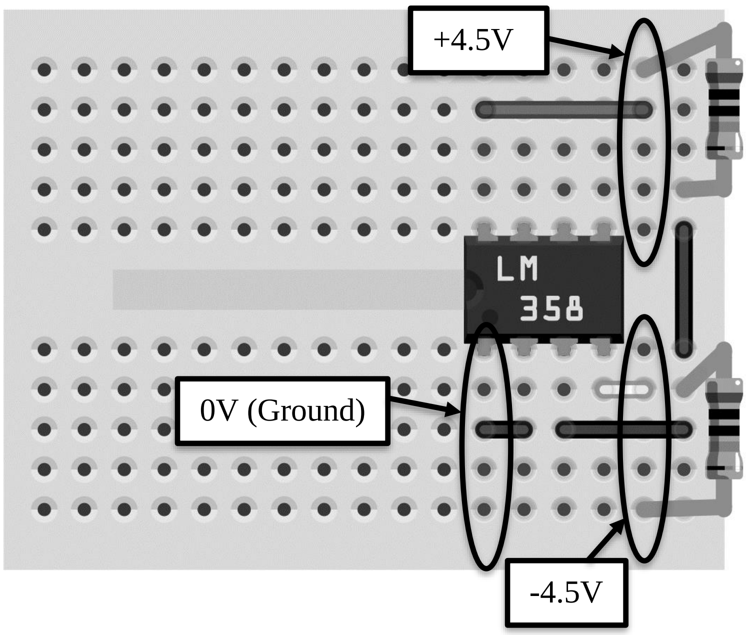


Step 2: Next we'll use one of our op-amps for a "voltage-follower" circuit. This circuit ensures that no matter how much power the op-amp draws, the ground of the circuit will stay in the middle of the two "power rails" being +4.5 and -4.5V, making it far more "sturdy". Because the input of the op-amp is connected to the middle of the voltage divider, the output will be our ground.

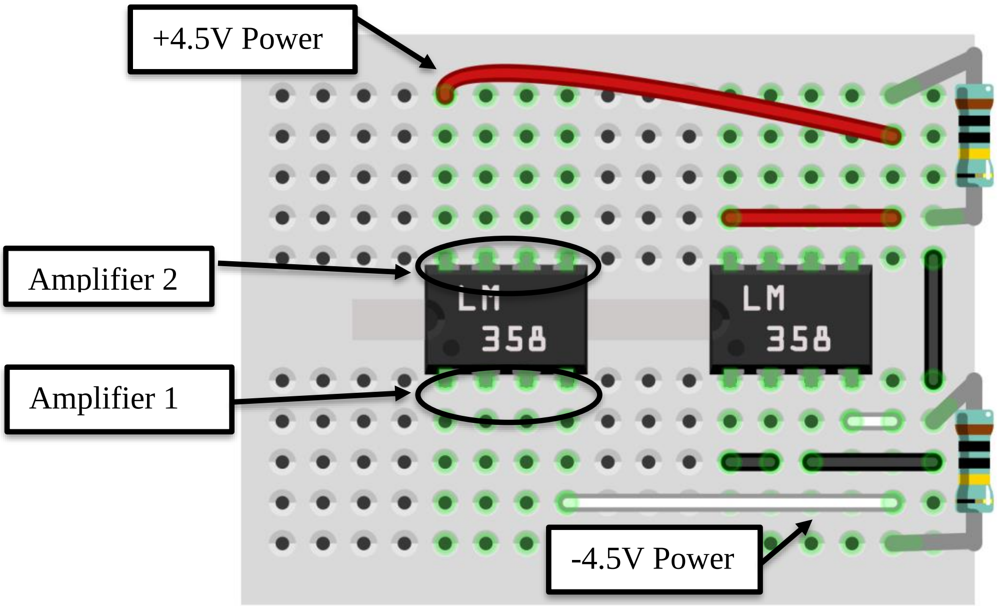
<u>Components:</u>



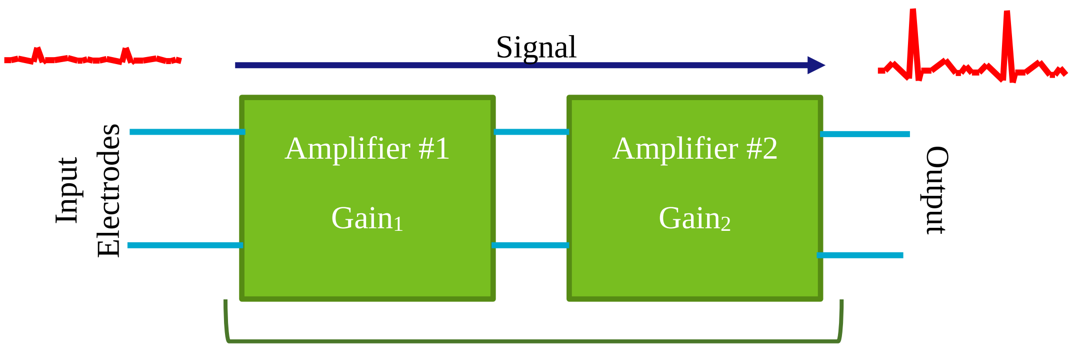
<u>Voltages:</u>



Step 3: Next we'll place the other op-amp on the board, and connect it to our power supply circuit. Be sure to place it carefully because there is limited space on the breadboard. This is the op-amp chip that contains both amplifiers used to amplify your heartbeat.



The two amplifiers in this chip work together to boost your heartbeat signal. The "gain" of an amplifier is the number it multiplies the original signal by. When you have several amplifiers, you can multiply their gains together to produce even greater gains. The figure below shows how the two amplifiers in the chip work together to produce the total gain.



$$\text{Gain}_{\text{total}} = \text{Gain}_1 * \text{Gain}_2$$
$$\text{Output} = \text{Gain}_{\text{total}} * \text{Input}$$

Step 4: Next you'll find the total gain needed for you ECG. The electrocardio signal on the surface of your forearms is roughly 0.5 mV, or **0.0005 V** (Input). In order for it to be seen by your computer, it needs to be amplified to about **1V** (Output).

Heartbeat Voltage (Input): ____________________V

Amplified Voltage (Output): ___________________V

$$Output = Gain_{total} * Input$$

$Gain_{Total}$: ____________________

Because these amplifiers aren't intended for a gain that high, we'll split the gain between two of the amplifiers. Because of filtering, the gain of the second amplifier should be kept to 20. Keeping this in mind, you can find the gain of the first amplifier.

$$Gain_{total} = Gain_1 * Gain_2$$

Gain of Amplifier 1 ($Gain_1$): ____________________

Step 5: The circuit below shows the resistor configuration for the first amplifier on a breadboard. One question that needs answering though, is which resistors to use. Each amplifier has *input* resistors and *feedback* resistors. Input resistors are connected to the input signal while feedback resistors connect one of the inputs to the output. Depending on which resistors you use for each, you can choose the gain of the amplifier. The first amplifier has two feedback resistors of the same value and two input resistors of the same value. Based on your answer above, use the equation below to find the ratio of feedback resistance to input resistance.

$$Gain_1 = 1 + \frac{R_{feedback1}}{R_{input1}}$$

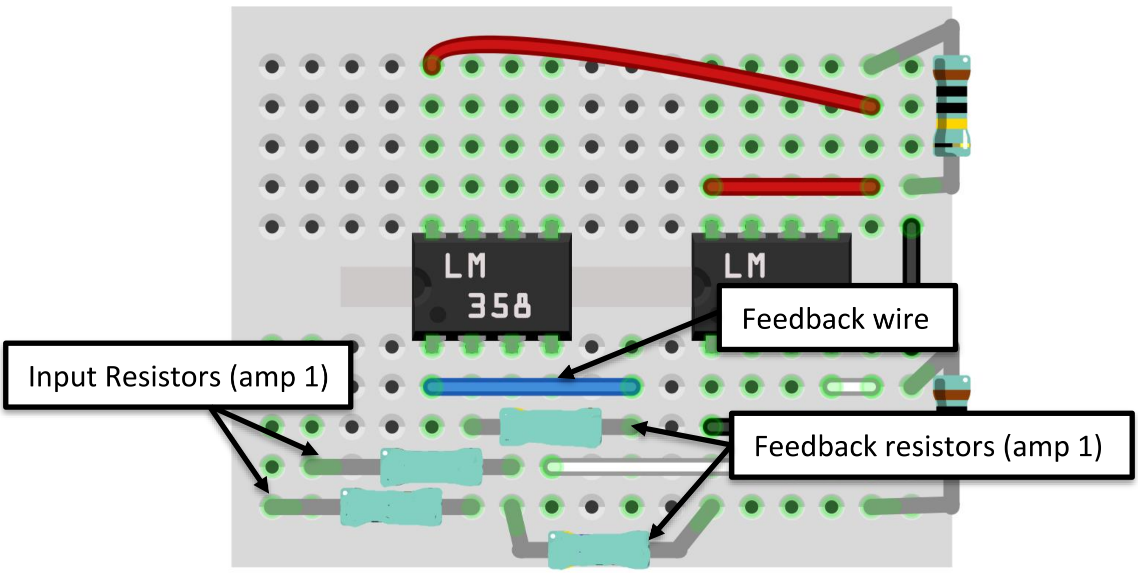
$R_{feedback1}/R_{input1}$ = ______________________

Using the available resistors, can you find which two resistors will give you this ratio?

$R_{feedback1}$ = _____________kΩ

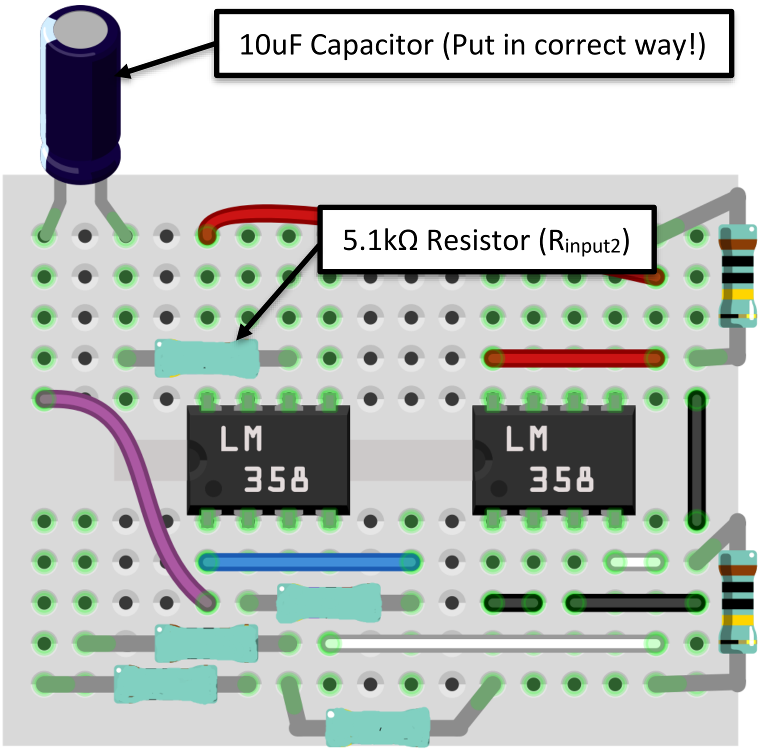
R_{input1} = _______________kΩ

Once you've chosen resistors for your circuit, place them in the breadboard as shown below. You also may need a feedback wire to connect $R_{feeback1}$ to pins 1 and 2.



Step 5: Next we'll connect our first amplifier's output to the second amplifier's input through a capacitor and a resistor. This capacitor and resistor create a filter to eliminate low-frequency "noise" from the circuit. A 5.1kΩ resistor (R_{input2}) and 10uF capacitor create a cutoff frequency of

about 3 Hz (it lets noise with a frequency higher than 3Hz through), so we'll use those two components. Place a wire across the center-divider of the board and insert the components as shown below, connecting one end of the resistor to pin 6 of the LM358 and the other to the positive pin of the capacitor (no grey bar). The negative end of the capacitor (marked by a grey bar) should be connected to the output of the first amplifier, shown below as a purple wire.



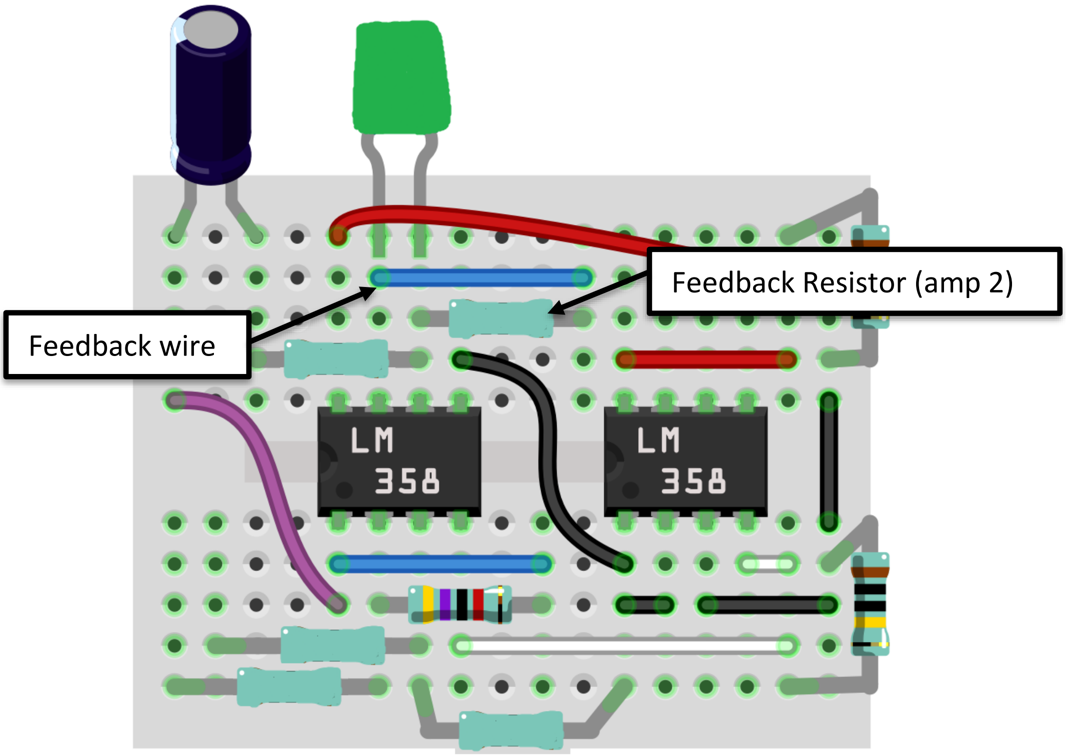
Step 6: The capacitor and resistor of the previous step provide the first half of the second amplifier configuration, but we still need to set the gain of the second amplifier. We'll do this using another feedback resistor and the input (5.1kΩ) resistor placed in the previous step (for the second amplifier, we only require one feedback and one input resistor). You may also need to use a feedback wire to connect the resistor to pins 6 and 7 of the amplifier. We know that the gain of this amplifier must be 20 ($Gain_2$) from Step 4, and the equation below still applies:

$$Gain_2 = 1 + \frac{R_{feedback2}}{R_{input2}}$$

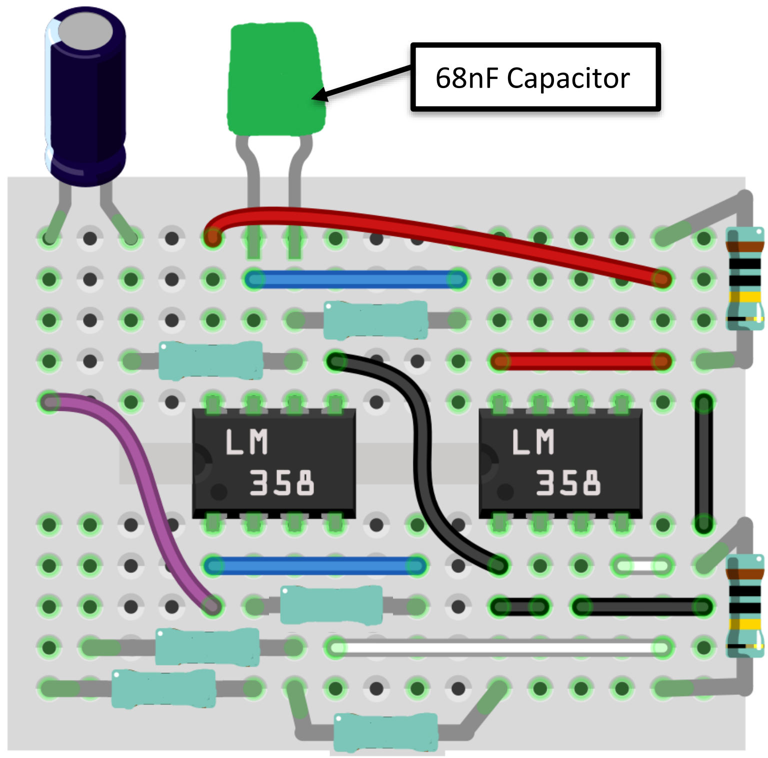
What resistor do you have handy that can be used for $R_{feedback2}$, and will generate the correct gain?

$R_{feedback2}$ = ____________________kΩ

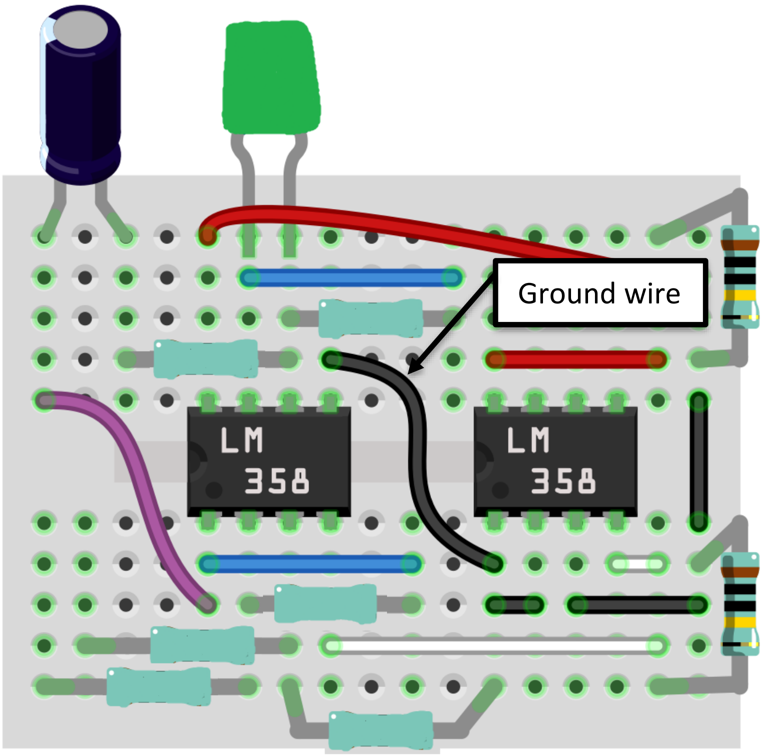
Place $R_{feedback2}$ into the circuit as shown below.



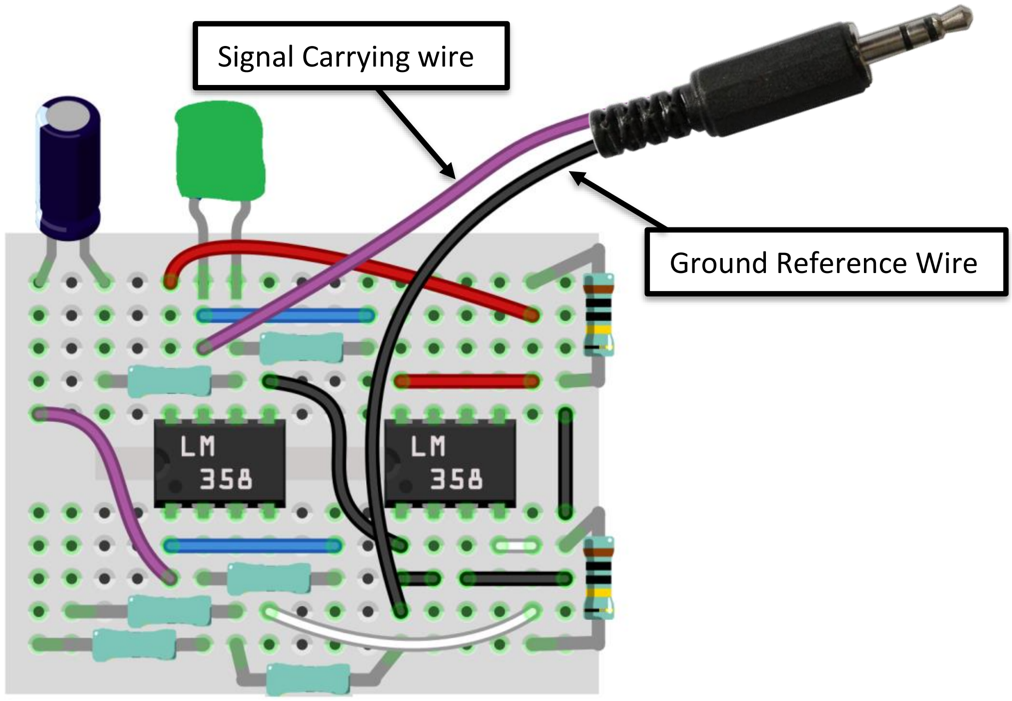
Step 7: Also place a 68nF capacitor between pins 6 and 7 of the LM358 as shown below. This filters out frequencies that are too high to be a heartbeat. This capacitor is not polarized so it can go either way.



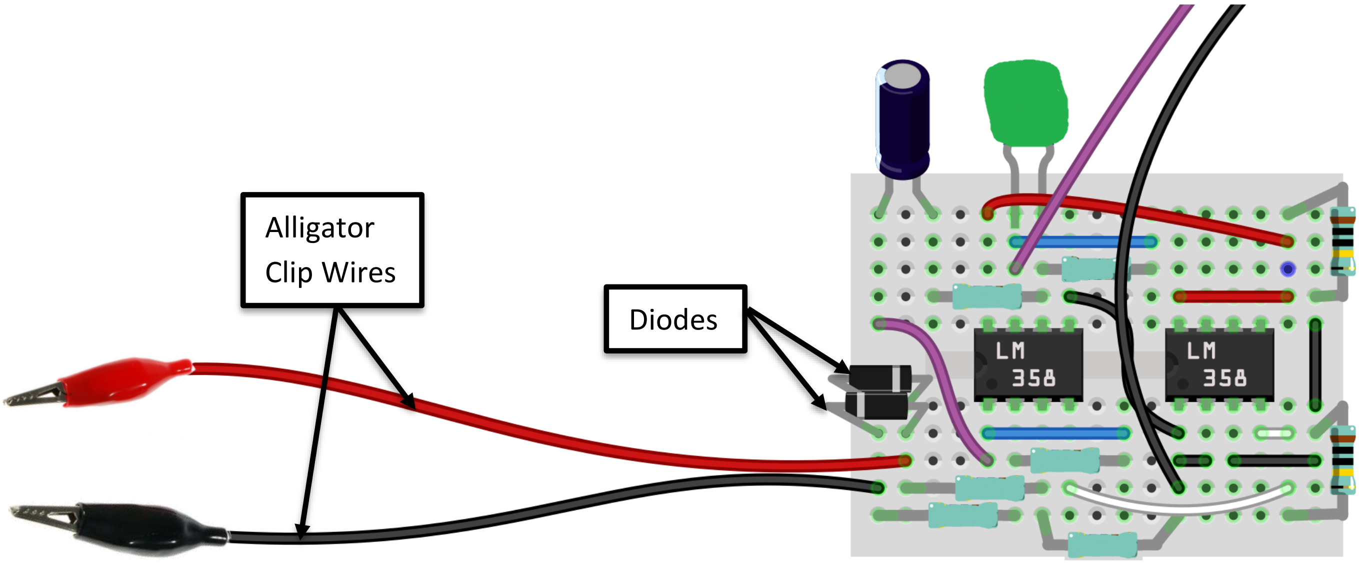
Step 6: Connect the two LM358's together as shown below. The rightmost one provides the ground for the second one, so you'll connect pin 1 of the right one to pin 5 of the left one, as shown below.



Step 7: You're ECG circuit is nearly complete! Next you'll add long wires to be connected to your audio jack. One of these must be connected to ground (pin 1 of the first LM358 chip) and the second wire must be connected to pin 6 of the second LM358. This is shown in the image below.

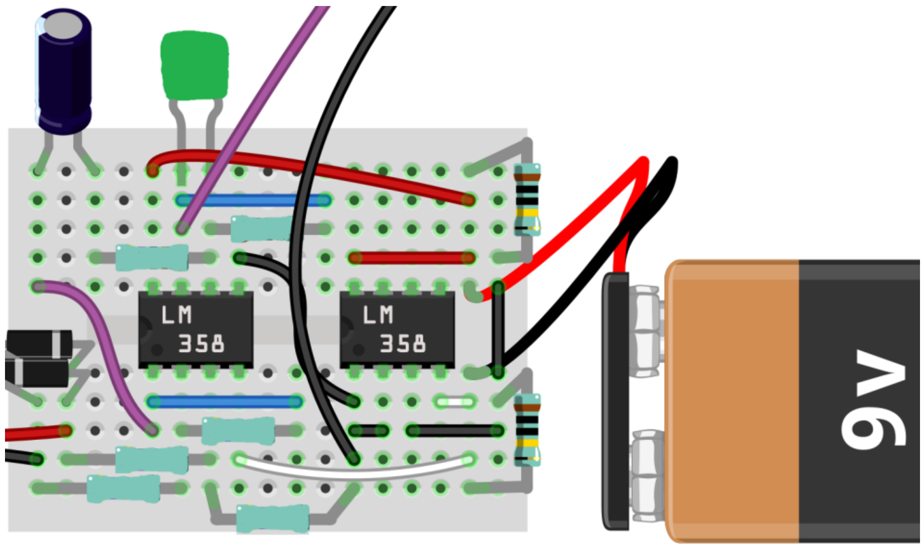


Step 8: Next we'll connect the input wires and 2 diodes to our circuit. The diodes are important because they protect the user from too much voltage. If a voltage spike is detected, they will allow current to flow through them rather than through the user. The grey bar on one end tells you the polarity, make sure that they are each going a different direction. For inputs, we'll connect two long alligator-clip wires to the circuit as shown below. These will be connected to electrode pads you can stick to your forearms.



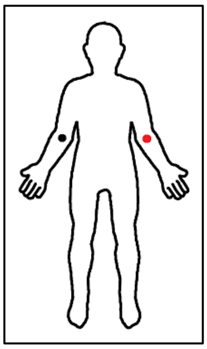
Step 9: Next, have a presenter check your circuit to ensure that there are no big mistakes. If your circuit seems to be made correctly, they'll have you go on to the next step.

Step 10: To finish off your ECG, you'll connect power to your circuit. To do this press a battery cap onto a 9V battery. Then attach the leads to the two ends of your voltage divider as shown below.

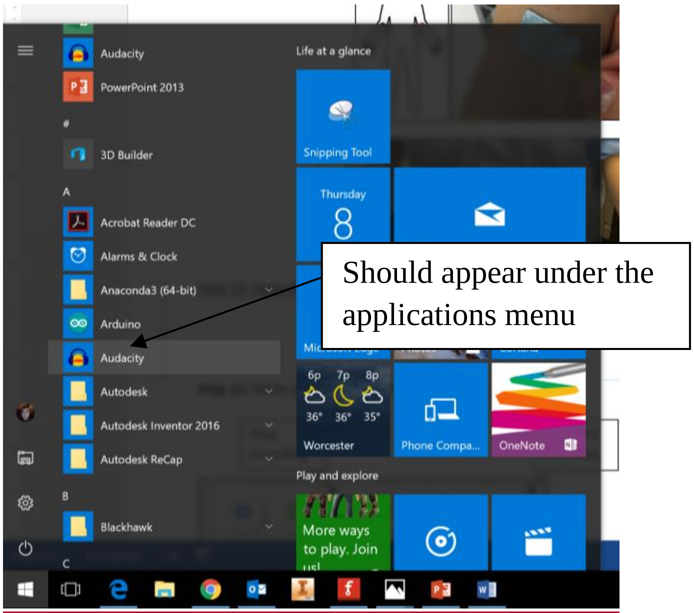


Step 11: Insert audio plug into the USB adapter. The audio connector must be connected into the *microphone* jack, not the headphone jack. And insert the USB adapter into a USB port on your computer.

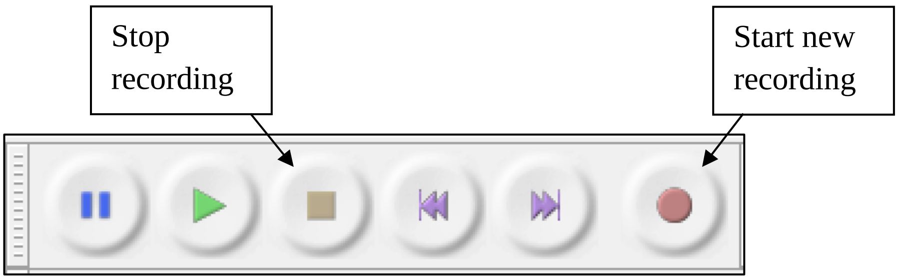
Step 12: Place the electrodes on your forearm as shown in the diagram below, and then attach the alligator clips to the electrodes.



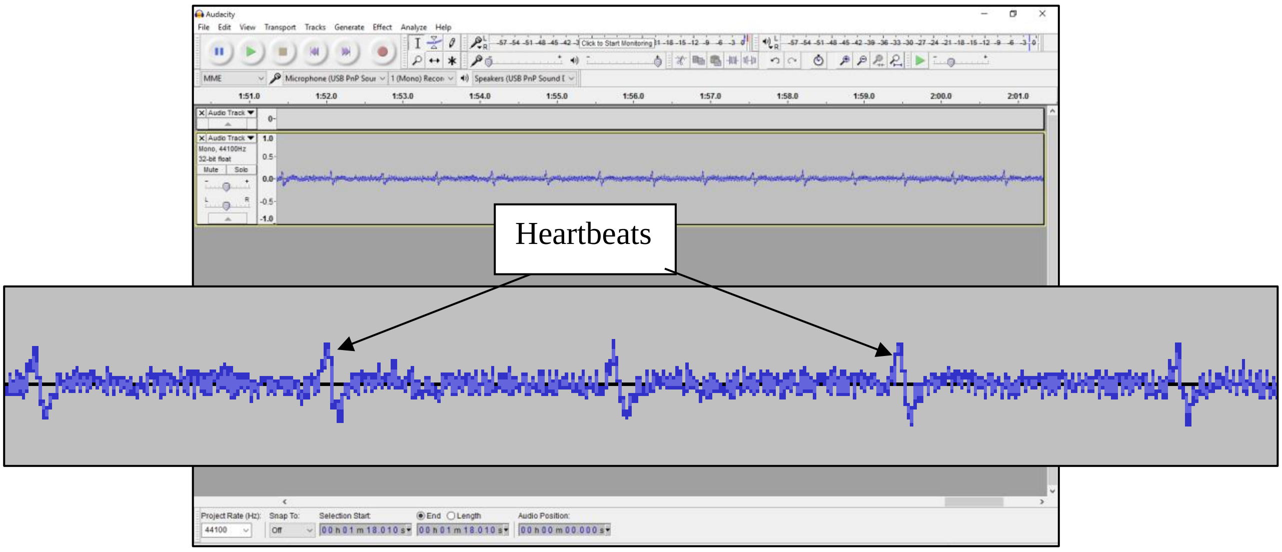
Step 13: Open the Audacity software.



Step 14: Make your first recording on your ECG.

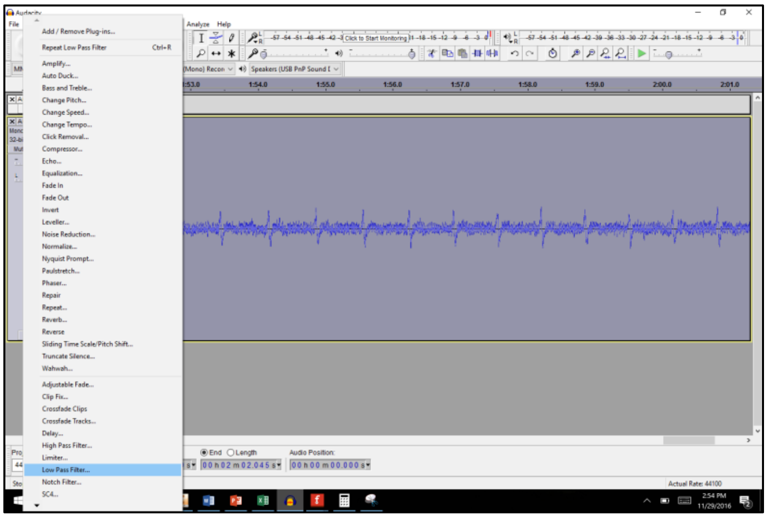


Ideally, you'll see a reading like the one below:

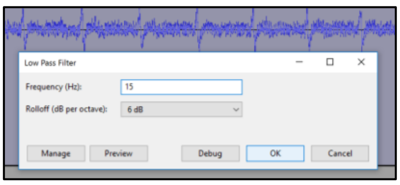


If you do not have a reading like the one above, you may need to do more filtering before you see your heartbeat. After stopping the recording, continue to step 14. If you don't have any noise at all on the output (the fuzzy lines between the heartbeats) then you need to troubleshoot your ECG. Ask a presenter for the troubleshooting guide.

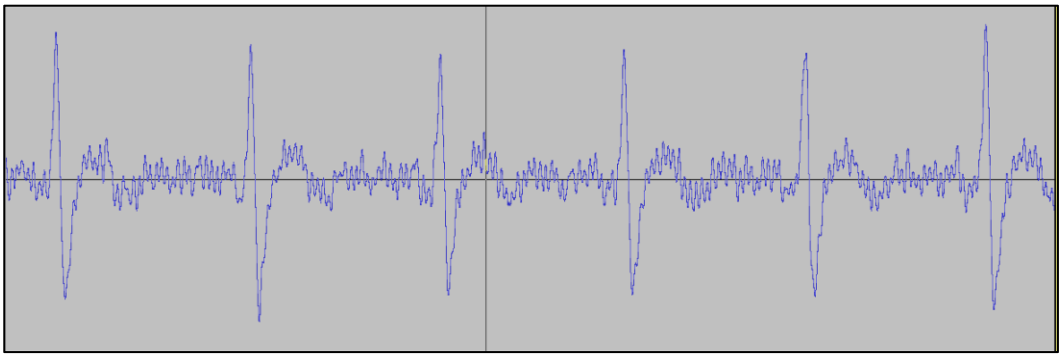
Step 15: It's time to do a little digital filtering of the signal. In Audacity, highlight a portion of your heartbeat that you want to clarify by clicking and dragging the cursor. Hover your cursor over the effects tab at the top of the application menu, then click on "lowpass filter".



The menu that follows allows you to choose a cutoff frequency (frequencies above which signals will be cut). 15Hz works fairly well for the ECG, because most of the electromagnetic noise in the room (radio stations, power outlets, etc.) have a frequency above 15Hz.



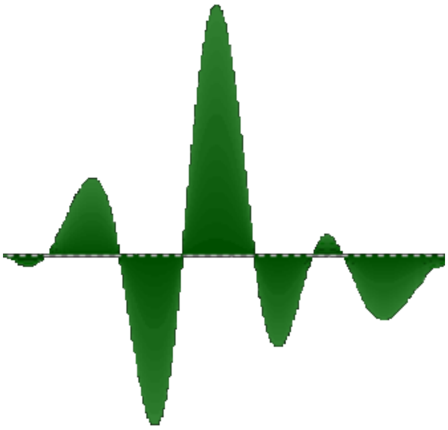
You can also “normalize” your signal to make it easier to see. This raises the signal to a “normal” volume. This is under the same effects menu. Leave the default settings and click okay. The final ECG output is shown below.



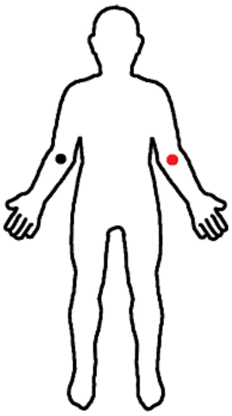
If you still can’t see your heartbeat, try doing the filtering step and the normalize step several more times. If it still doesn’t work, you may need to use the troubleshooting guide.

After ECG Construction Instructions

Parts of the Heartbeat
Can you identify which part of the wave makes which part of the heart contract? Label as many additional parts of the wave as you can.



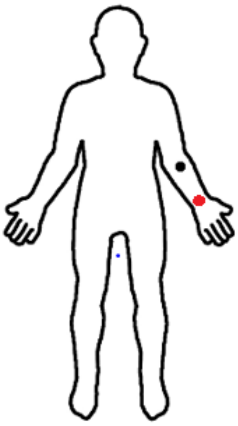
Testing your ECG
Put the positive lead on your left arm and the negative lead on the right arm. Record your resting heartbeat below.



Once you get used to the process of taking and then filtering the reading, try the activities on the next page.

Activity	What do you think will happen?	What happened?	Why did this happen?
Do some Push-ups/lunges, then use the ECG			
Do some jumping jacks, then use the ECG			
Do some deep breathing while attached to the ECG			
Switch the locations of the leads to 			
Switch the locations of the leads to 			

But wait, there's more!



The ECG you made also works as an EMG. You can attach them as shown or position them similarly across your bicep. Move these muscles, and see what happens. Make sure not to move the leads! This time use a low pass filter of 6 and a high pass filter of 4.

Design an Experiment to answer the following questions:
Does how much effort you put into a movement affect the EMG reading? Remember to write down your hypothesis, methods, results, and conclusions.

Any others questions? - make another experiment to figure it out!

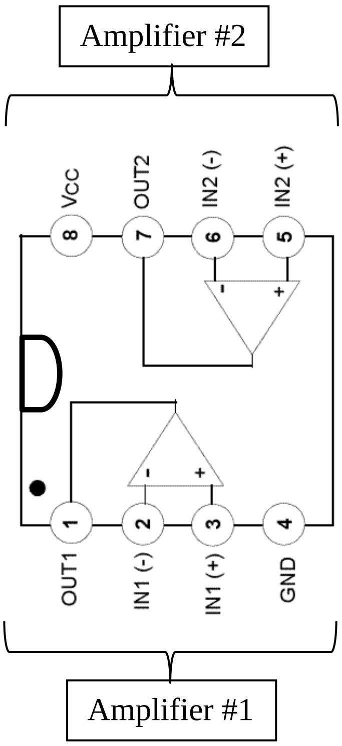
Available Resistors

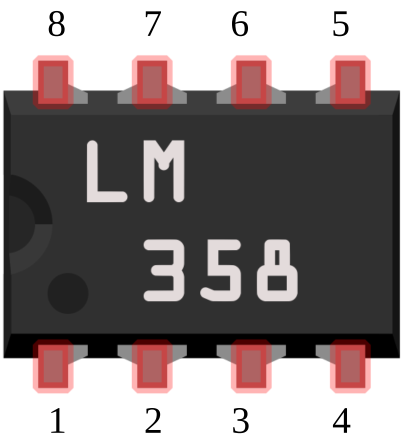
You've only got a few resistors handy to make your ECG work:

Value	Colours
1 kΩ (1000 Ω)	brown-black-black-brown-brown
5.1 kΩ (5,100 Ω)	green-brown-black-brown-brown
100 kΩ (100,000 Ω)	brown-black-black-red-brown
10 MΩ (1,000,000 Ω)	Brown-black-black-green-brown

Knowing your pins

The LM358 has 8 pins (the little legs of the bug). Two of these pins are used for power. The other six pins are used for the amplifiers. Each has two for inputs and one for an output. They are numbered counter clockwise from the pin below the half-moon crescent shape, as shown below:





ECG Troubleshooting Guide

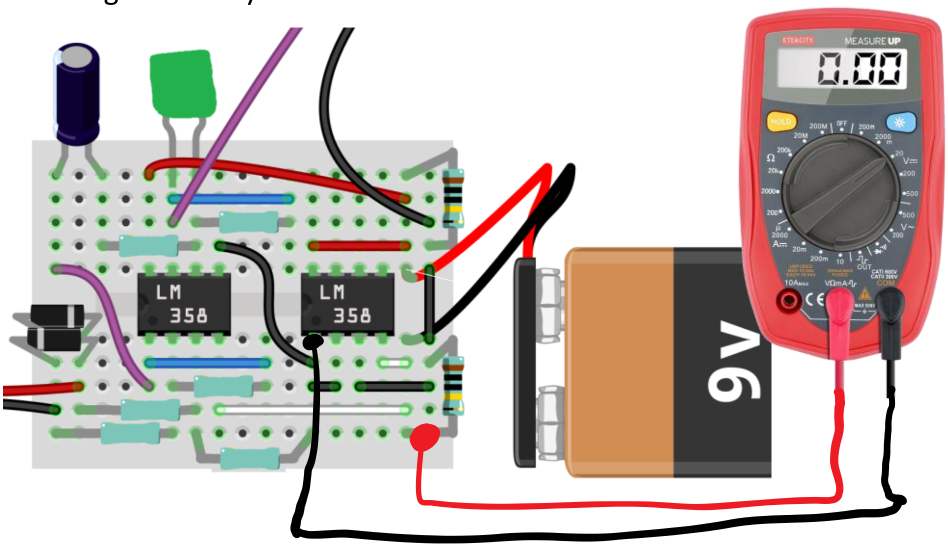
So you've completed your ECG but still haven't seen a heartbeat? Don't fear! There are some quick and simple solutions that may work for you!

Disconnect the ECG from your Computer

Before conducting any troubleshooting, be sure to disconnect your ECG from your computer! This ensures that no damage can happen to your USB port.

Check your power circuit

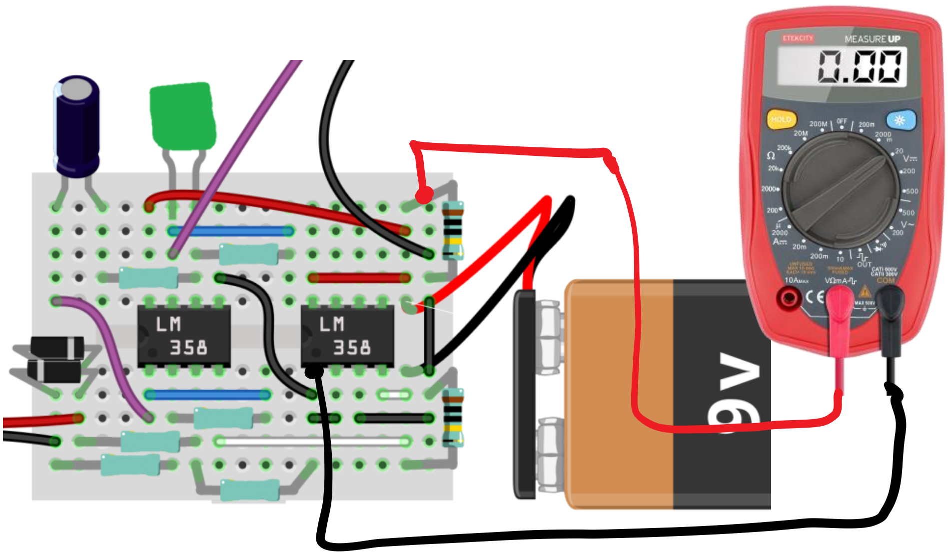
If your amplifiers aren't getting any power, they won't be able to amplify much! Ensure the multimeter dial is set to V (voltage), and 20 (so that it can measure voltages between 0 and 20V). Touch the red probe to the ground of your circuit, and the other to the negative end of your voltage divider as shown below. It should read between -5V and -3V. Also check it between the ground and the positive end of your voltage divider. If the values are off, there is a misconnection in the right half of your breadboard.



Should be between -5 and -3V

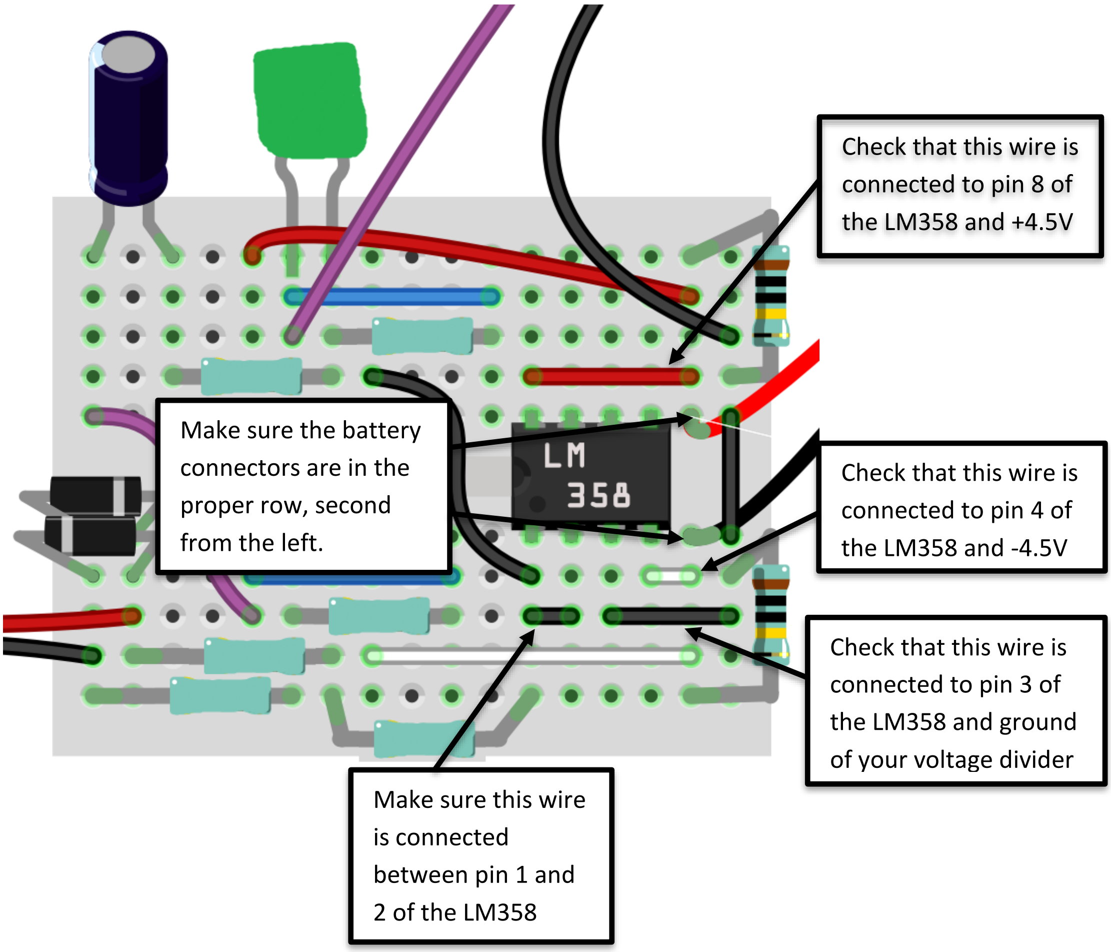
Note!

If multimeter is being used and unavailable, continue on to next steps and come back later!



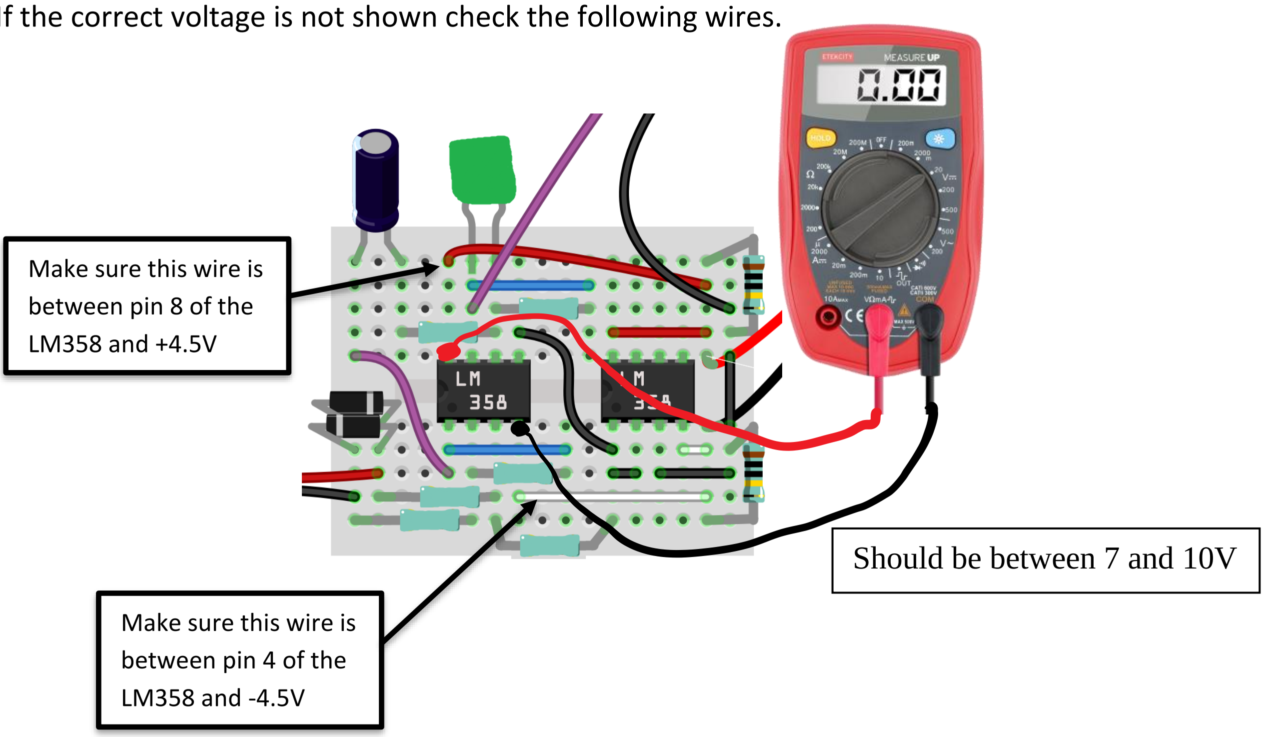
Should be between 5 and 3V

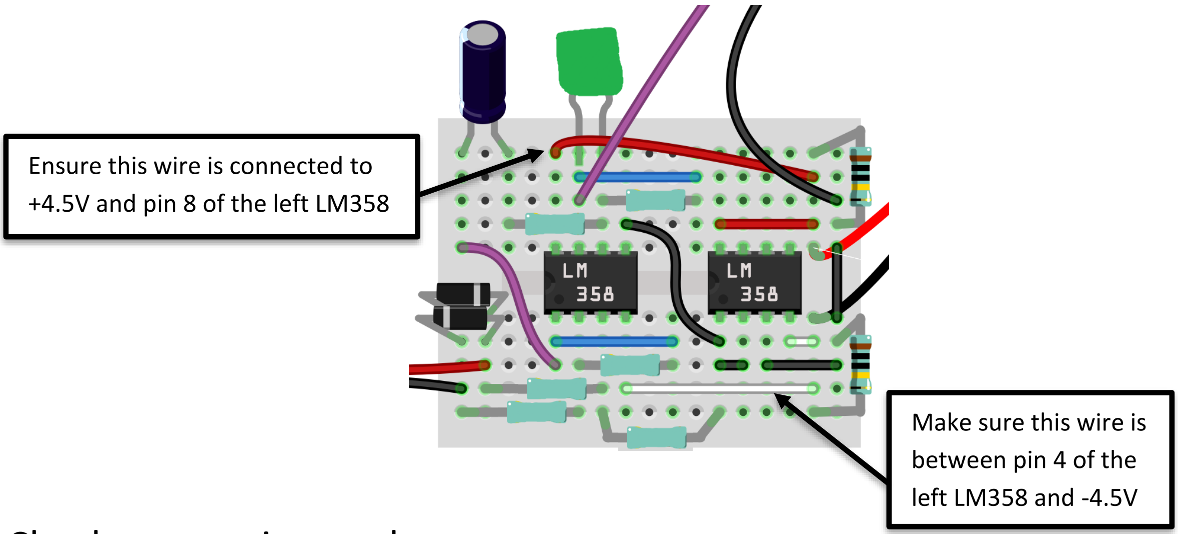
If the voltages are correct, you can move on to the next step. If the voltages are not as they should be, ensure that you didn't connect the multimeter leads backwards, and then check the following wires:



Make sure your ECG Amplifier has power

Check to make sure your ECG amplifier has power! Connect the multimeter as shown below. If the correct voltage is not shown check the following wires.

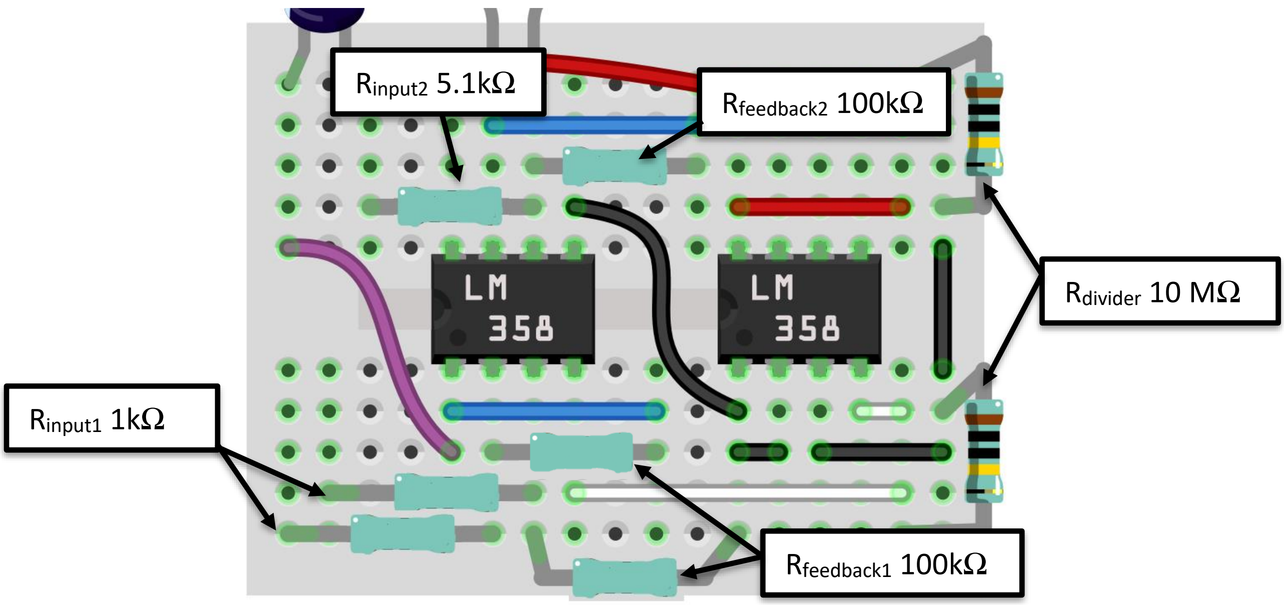




Check your resistor values

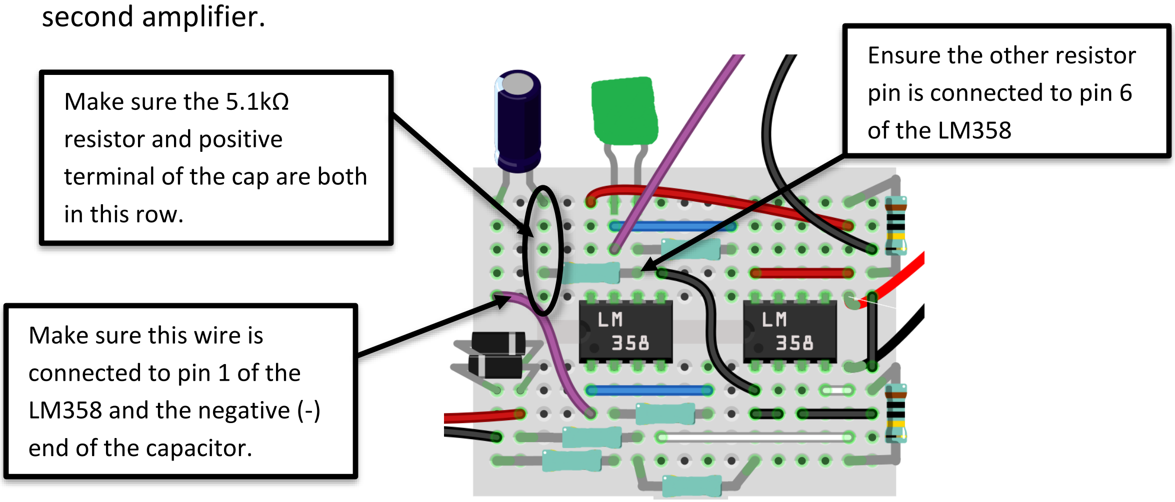
You may have accidentally grabbed the wrong resistors! Check with a neighbour and see if they have the same resistors (look at the colour codes) in the same place as you. If you're still not sure, check your resistor values and colours below.

Name	Quantity	Value	Colours
R_{input1}	2	1 kΩ	brown-black-black-brown-brown
$R_{feedback1}$	2	100 kΩ	brown-black-black-red-brown
R_{input2}	1	5.1 kΩ	green-brown-black-brown-brown
$R_{feedback2}$	1	100 kΩ	brown-black-black-red-brown
$R_{divider}$	2	1 MΩ	Brown-black-black-green-brown



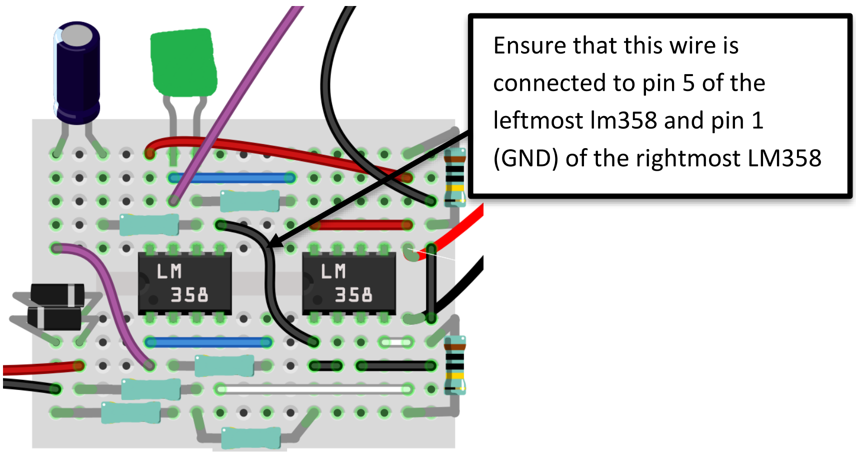
Make sure your amplifiers are wired together

The output of the first amplifier is pin 1 and the input of the second amplifier is pin 6. The signal needs to travel through the capacitor and the amplifier 2 input resistor in order to get to the second amplifier.



Make sure second amplifier is connected to ground

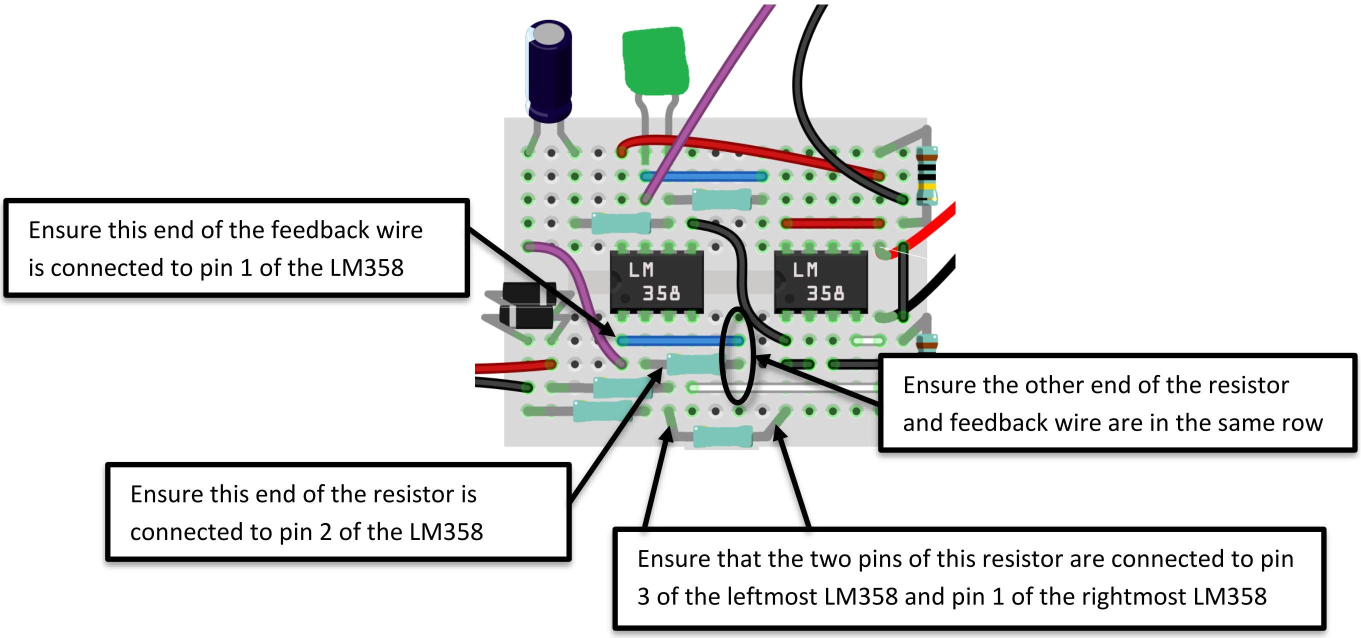
In order for the second amplifier to be able to amplify the input signal, pin 5 must be connected to ground for reference.



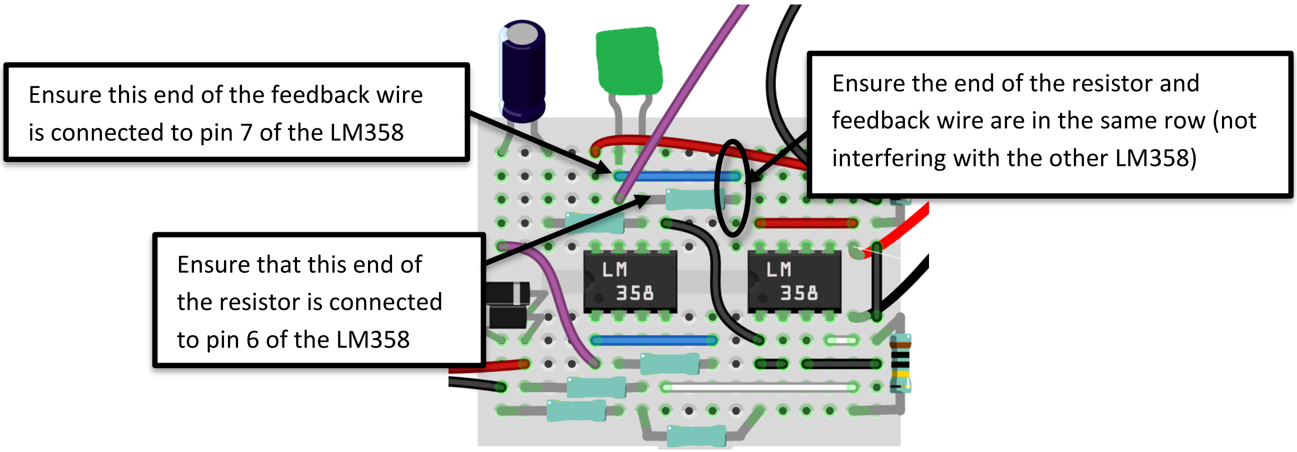
Feedback wire connected to wrong pin

It's often easy to trip-up where the feedback resistors and wires are supposed to connect on the chip. Take a minute to double check those.

<u>Feedback Loop 1:</u>

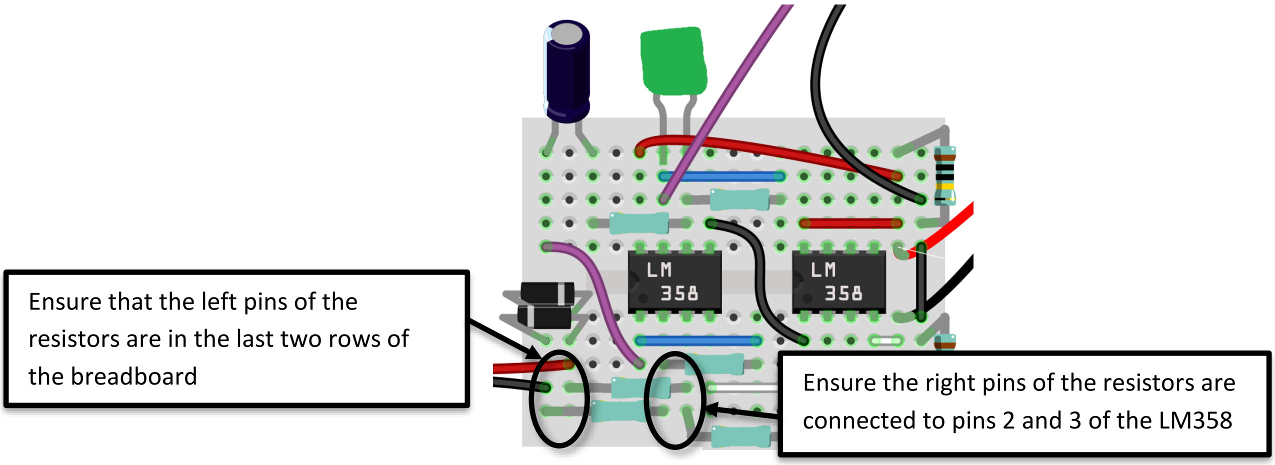


<u>Feedback Loop 2:</u>



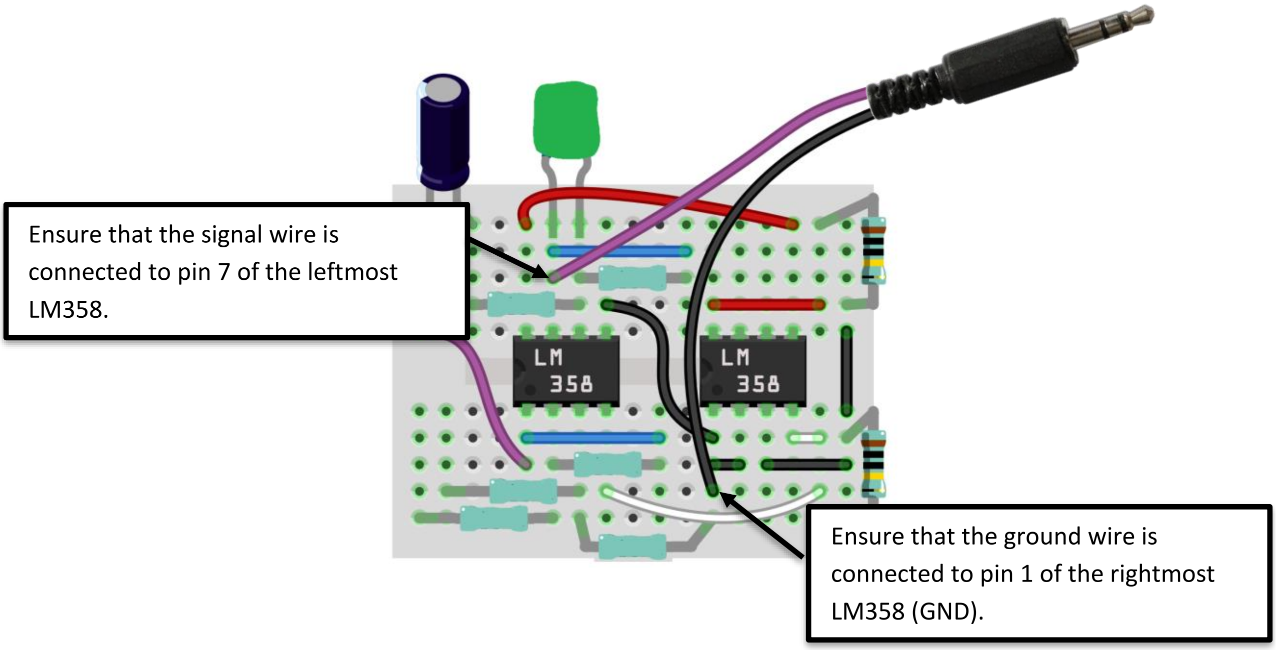
Check that input resistors are connected correctly

Sometimes the input resistors are not connected to the correct pins in the LM358.



Microphone Jack connected incorrectly

Sometimes the microphone jack isn't inserted properly into the breadboard. Check the connecting wires.



Alligator Clips may be broken

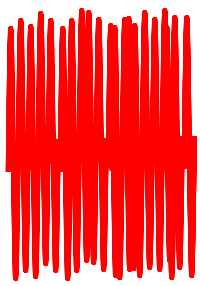
If all else fails, there may be a problem with your alligator clips. You can check them by turning the dial of the multimeter to the 200 ohms setting. If the multimeter reads a low decimal number (between 20 and 0) then the connection is good. If it reads just a 1 or an L, then

Step-by-Step Instructions for Simple ECG Construction with Solutions for Instructors

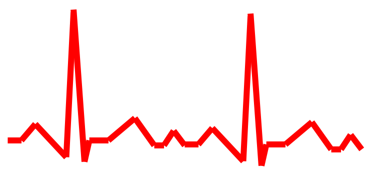
An electrocardiogram is a machine that records or displays a person's heartbeat. Essentially, it senses the electrical impulses that your bodies uses to make your heart beat, and shows them on a monitor or, in this case, a computer.

By the time it reaches your arms, the electrical signal of your heart is very small (approximately 1mV), so it must be amplified many times to be seen by most computers (to approximately 1V). Because many electrical signals exist within the human body, the ECG must also filter out those signals.

Raw signal, too small to detect.

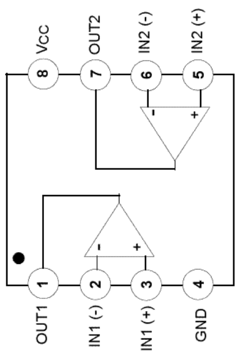


Signal after amplification, with plenty of noise.

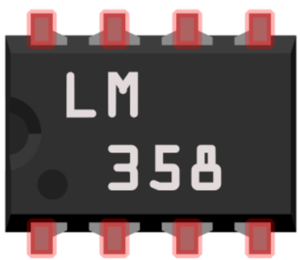


Amplified signal after filtering

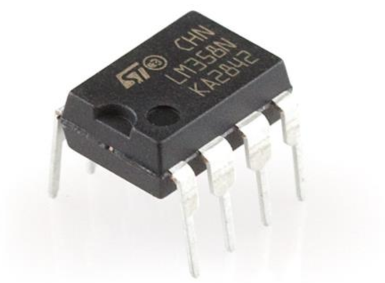
This activity uses three amplifiers to achieve this goal. Each LM358 chip conveniently has two amplifiers, three of which will be used for the electrocardiogram. The pin numbers are shown in the figure below. Starting at the half moon shape on the edge of the chip, the pins are numbered 1 through 8 moving counterclockwise. The first amplifier doesn't actually do any amplifying but helps create the right power sources in the circuit. The second two amplifiers both amplify the circuit.



Symbolic view of LM358



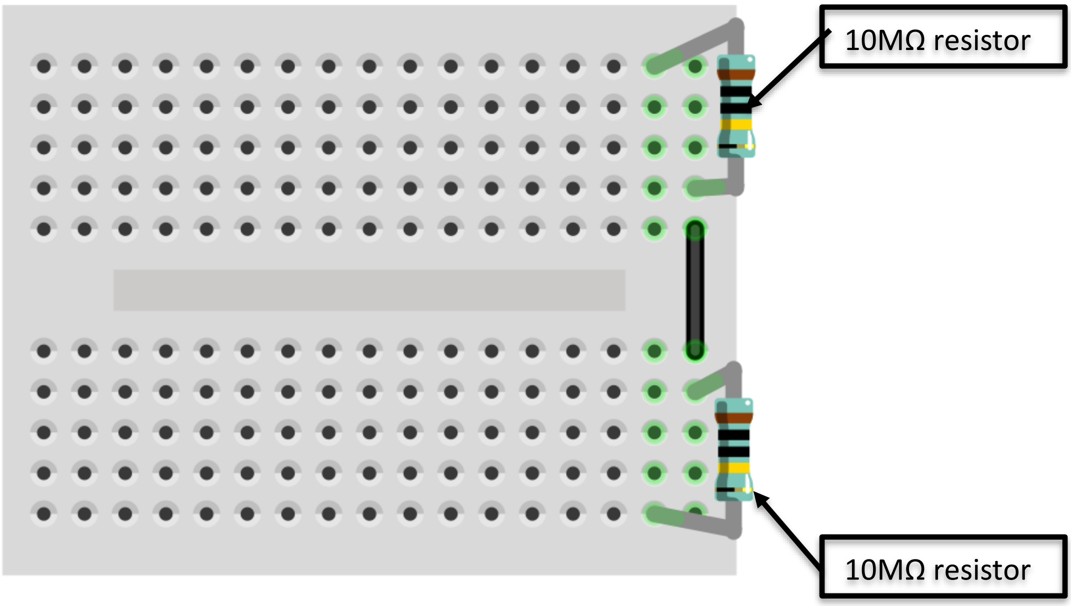
Breadboard view of LM358



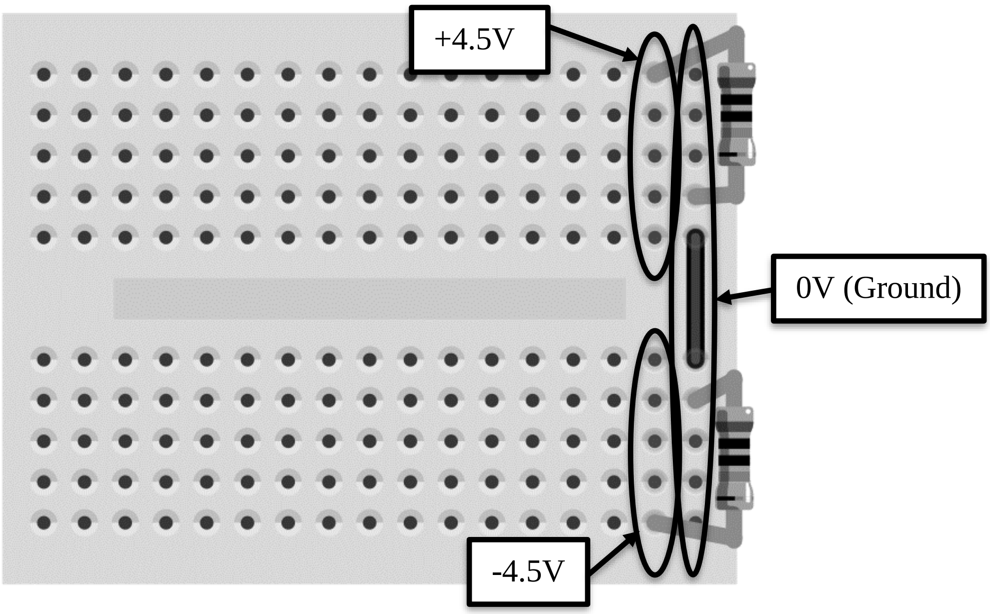
Actual view of LM358

Step 1: We'll start out by building the circuit to power your ECG. In order to have an output signal that is both positive and negative, we need to have both positive, and negative voltages (as well as a ground reference (0V). In order to do this, we'll divide the voltage over two 10MΩ resistors—known as a voltage divider. The terminals of the battery will be connected to the two ends of the divider. We'll use the middle of the divider as our "ground" or 0V mark. This makes the two ends of the divider +4.5V and -4.5V.

Components:



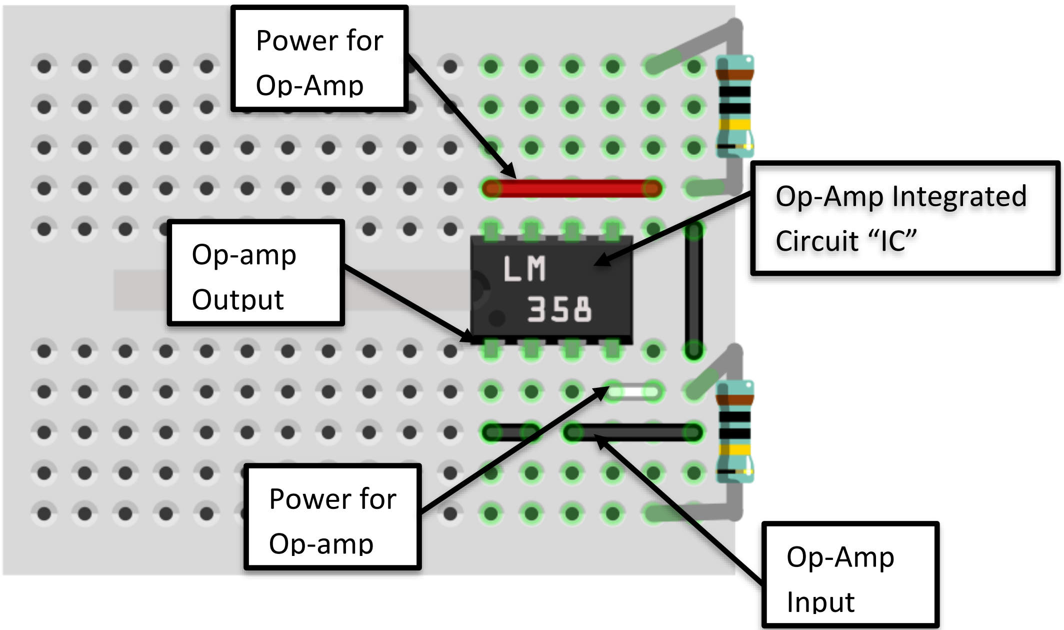
Voltages:



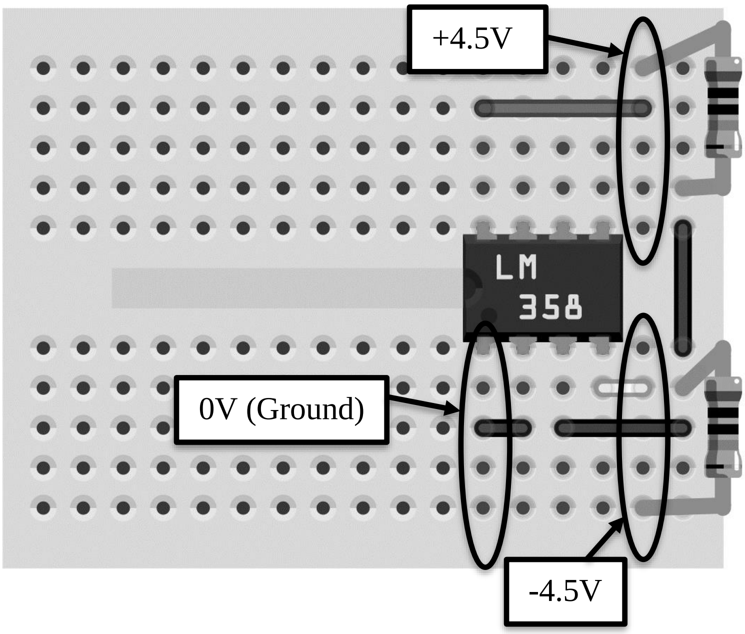
Step 2: Next we'll use one of our op-amps for a "voltage-follower" circuit. This circuit ensures that no matter how much power the op-amp draws, the ground of the circuit will stay in the middle of

the two "power rails" being +4.5 and -4.5V, making it far more "sturdy". Because the input of the op-amp is connected to the middle of the voltage divider, the output will be our ground.

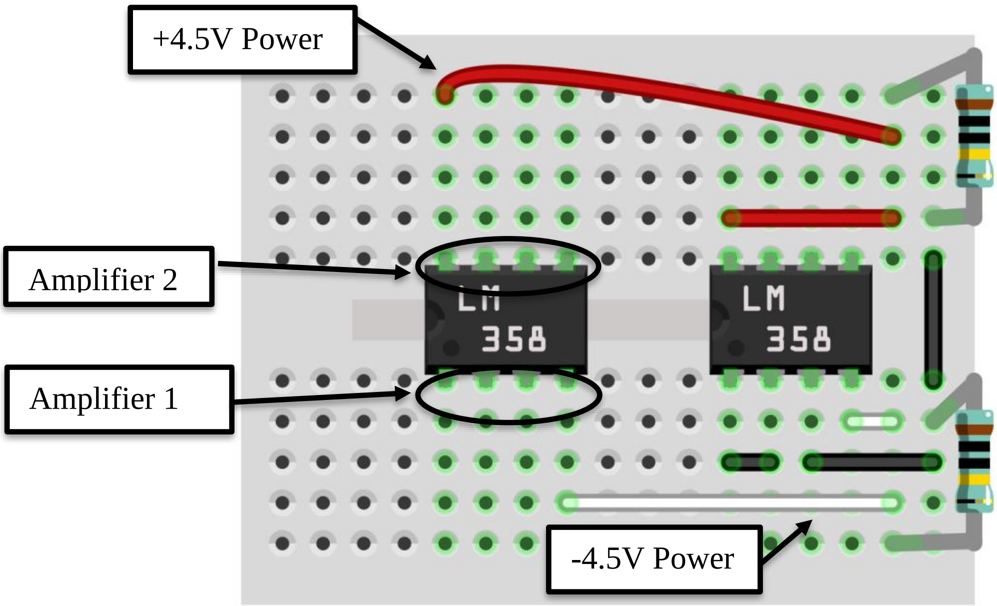
Components:



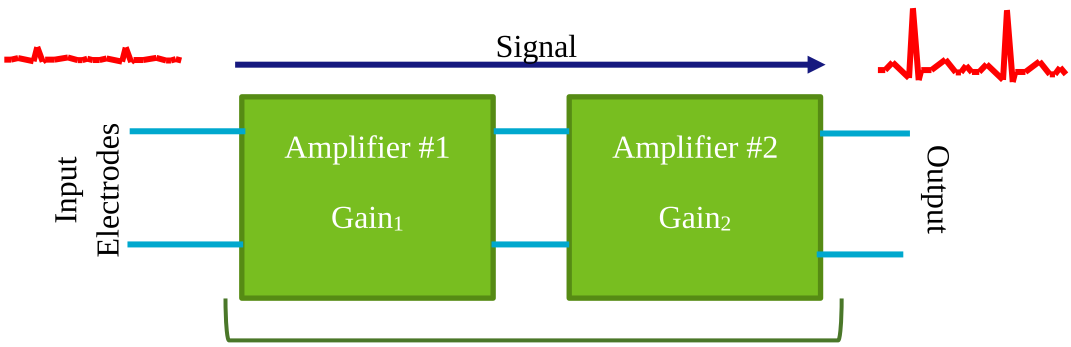
Voltages:



Step 3: Next we'll place the other op-amp on the board, and connect it to our power supply circuit. Be sure to place it carefully because there is limited space on the breadboard. This is the op-amp chip that contains both amplifiers used to amplify your heartbeat.



The two amplifiers in this chip work together to boost your heartbeat signal. The "gain" of an amplifier is the number it multiplies the original signal by. When you have several amplifiers, you can multiply their gains together to produce even greater gains. The figure below shows how the two amplifiers in the chip work together to produce the total gain.



$$\text{Gain}_{\text{total}} = \text{Gain}_1 * \text{Gain}_2$$
$$\text{Output} = \text{Gain}_{\text{total}} * \text{Input}$$

Step 4: Next you'll find the total gain needed for you ECG. The electrocardio signal on the surface of your forearms is roughly 0.5 mV, or **0.0005 V** (Input). In order for it to be seen by your computer, it needs to be amplified to about **1V** (Output).

Heartbeat Voltage (Input): ________0.0005________V

Amplified Voltage (Output): ______1V___________V

$$Output = Gain_{total} * Input$$

$\text{Gain}_{\text{Total}}$: ___2000______

Because these amplifiers aren't intended for a gain that high, we'll split the gain between two of the amplifiers. Because of filtering, the gain of the second amplifier should be kept to 20. Keeping this in mind, you can find the gain of the first amplifier.

$$Gain_{total} = Gain_1 * Gain_2$$

Gain of Amplifier 1 ($Gain_1$): ______100______

Step 5: The circuit below shows the resistor configuration for the first amplifier on a breadboard. One question that needs answering though, is which resistors to use. Each amplifier has *input* resistors and *feedback* resistors. Input resistors are connected to the input signal while feedback resistors connect one of the inputs to the output. Depending on which resistors you use for each, you can choose the gain of the amplifier. The first amplifier has two feedback resistors of the same value and two input resistors of the same value. Based on your answer above, use the equation below to find the ratio of feedback resistance to input resistance.

$$Gain_1 = 1 + \frac{R_{feedback1}}{R_{input1}}$$

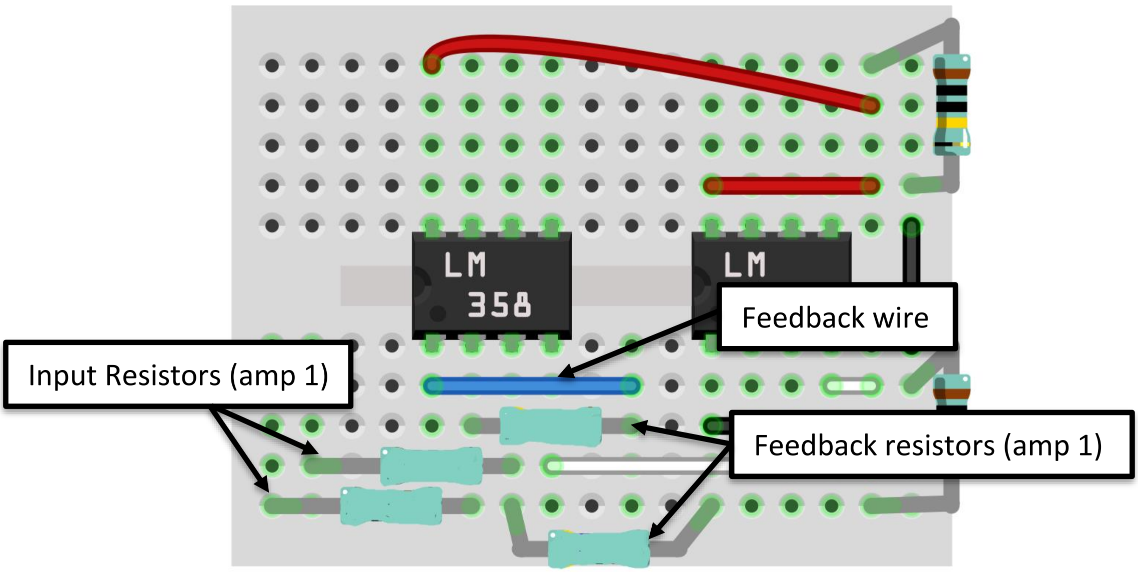
$R_{feedback1}/R_{input1}$ = ________99________

Using the available resistors, can you find which two resistors will give you this ratio?

$R_{feedback1}$ = ___100______kΩ

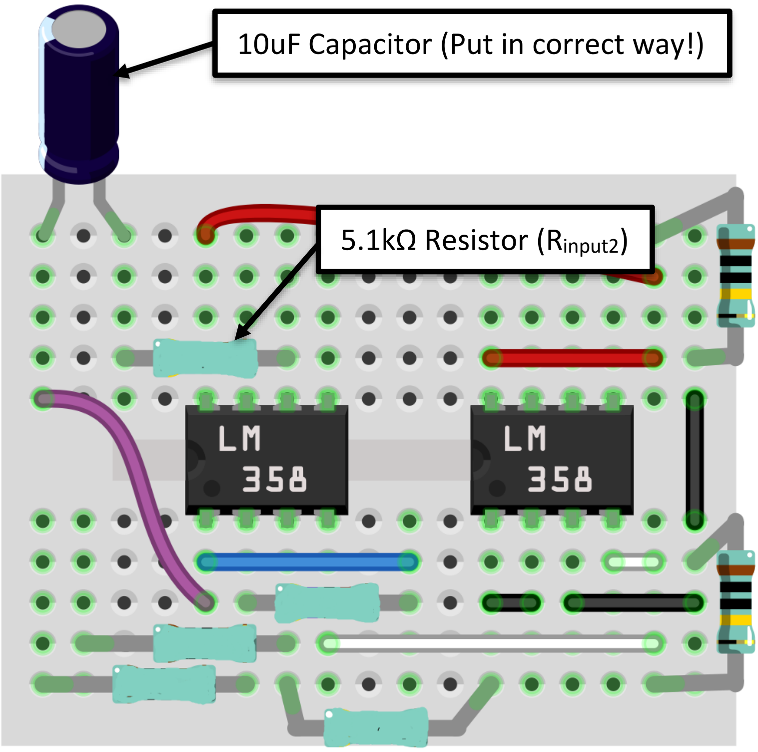
R_{input1} = ________1________kΩ

Once you've chosen resistors for your circuit, place them in the breadboard as shown below. You also may need a feedback wire to connect $R_{feeback1}$ to pins 1 and 2.



Step 5: Next we'll connect our first amplifier's output to the second amplifier's input through a capacitor and a resistor. This capacitor and resistor create a filter to eliminate low-frequency "noise" from the circuit. A 5.1kΩ resistor (R_{input2}) and 10uF capacitor create a cutoff frequency of about 3 Hz (it lets noise with a frequency higher than 3Hz through), so we'll use those two components. Place a wire across the center-divider of the board and insert the components as shown below, connecting one end of the resistor to pin 6 of the LM358 and the other to the

positive pin of the capacitor (no grey bar). The negative end of the capacitor (marked by a grey bar) should be connected to the output of the first amplifier, shown below as a purple wire.



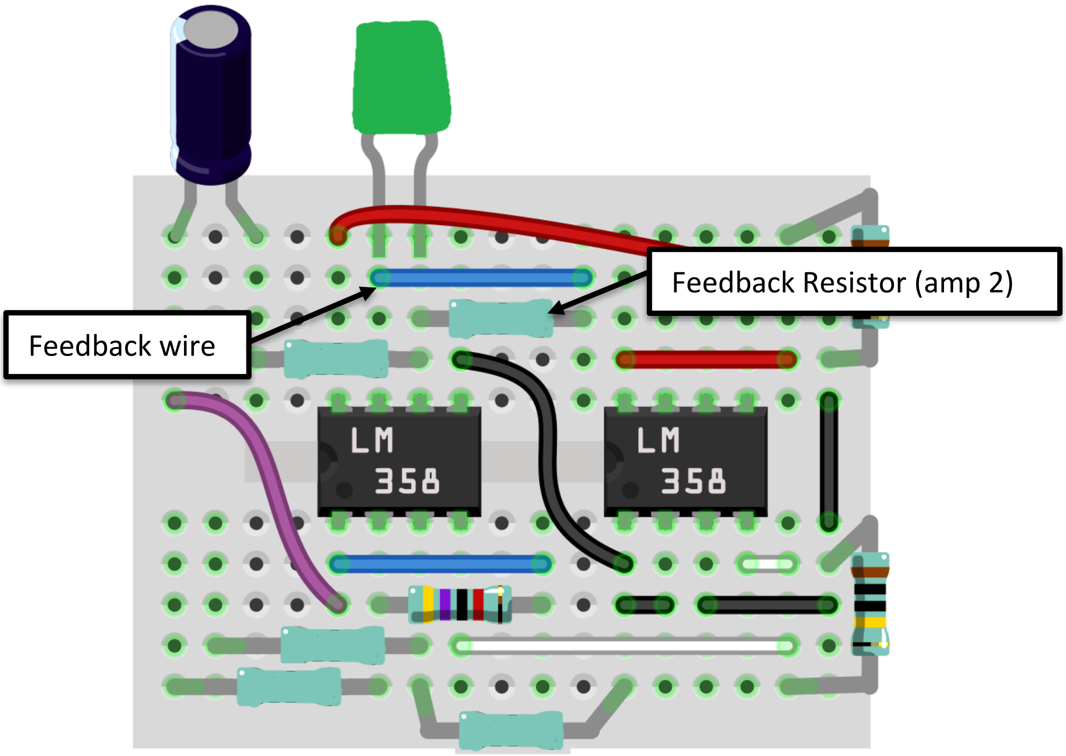
Step 6: The capacitor and resistor of the previous step provide the first half of the second amplifier configuration, but we still need to set the gain of the second amplifier. We'll do this using another feedback resistor and the input (5.1kΩ) resistor placed in the previous step (for the second amplifier, we only require one feedback and one input resistor). You may also need to use a feedback wire to connect the resistor to pins 6 and 7 of the amplifier. We know that the gain of this amplifier must be 20 ($Gain_2$) from Step 4, and the equation below still applies:

$$Gain_2 = 1 + \frac{R_{feedback2}}{R_{input2}}$$

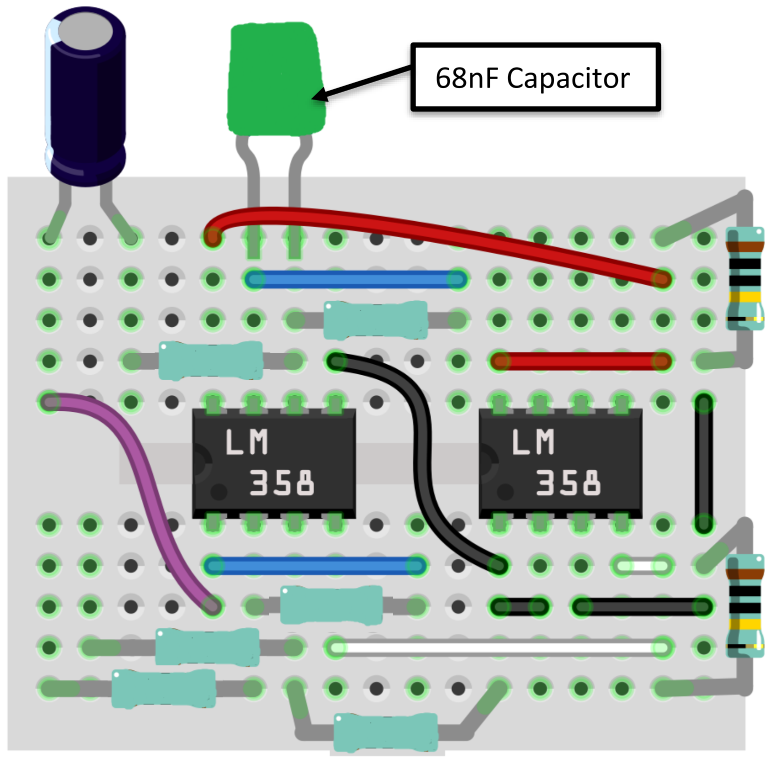
What resistor do you have handy that can be used for $R_{feedback2}$, and will generate the correct gain?

$R_{feedback2}$ = ______100________kΩ

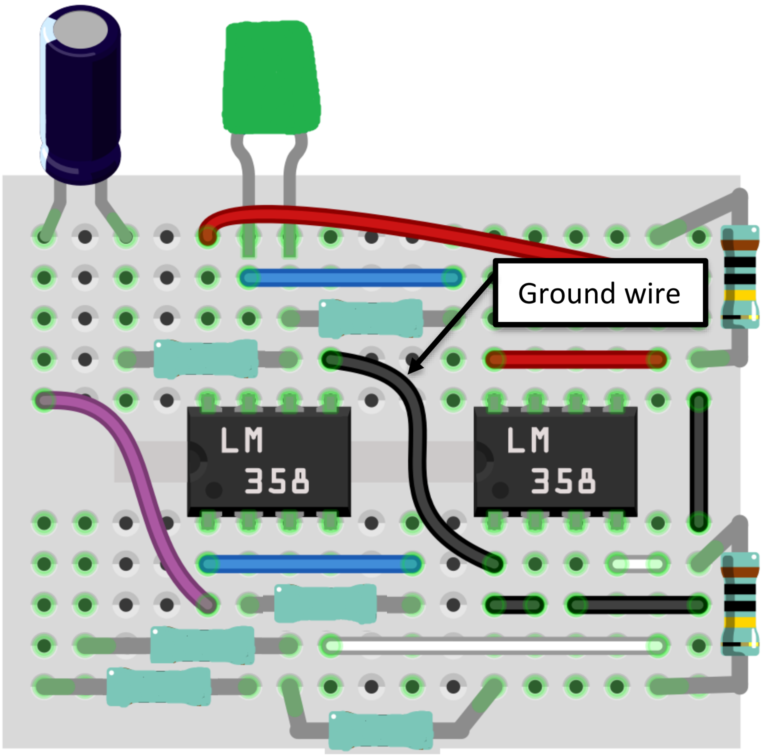
Place $R_{feedback2}$ into the circuit as shown below.



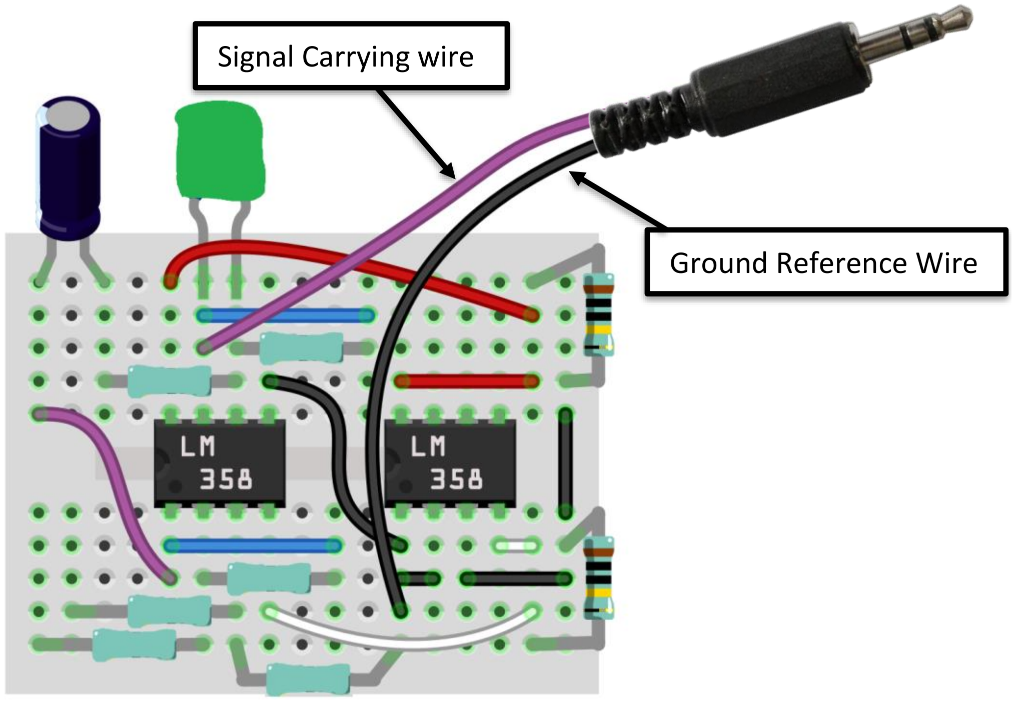
Step 7: Also place a 68nF capacitor between pins 6 and 7 of the LM358 as shown below. This filters out frequencies that are too high to be a heartbeat. This capacitor is not polarized so it can go either way.



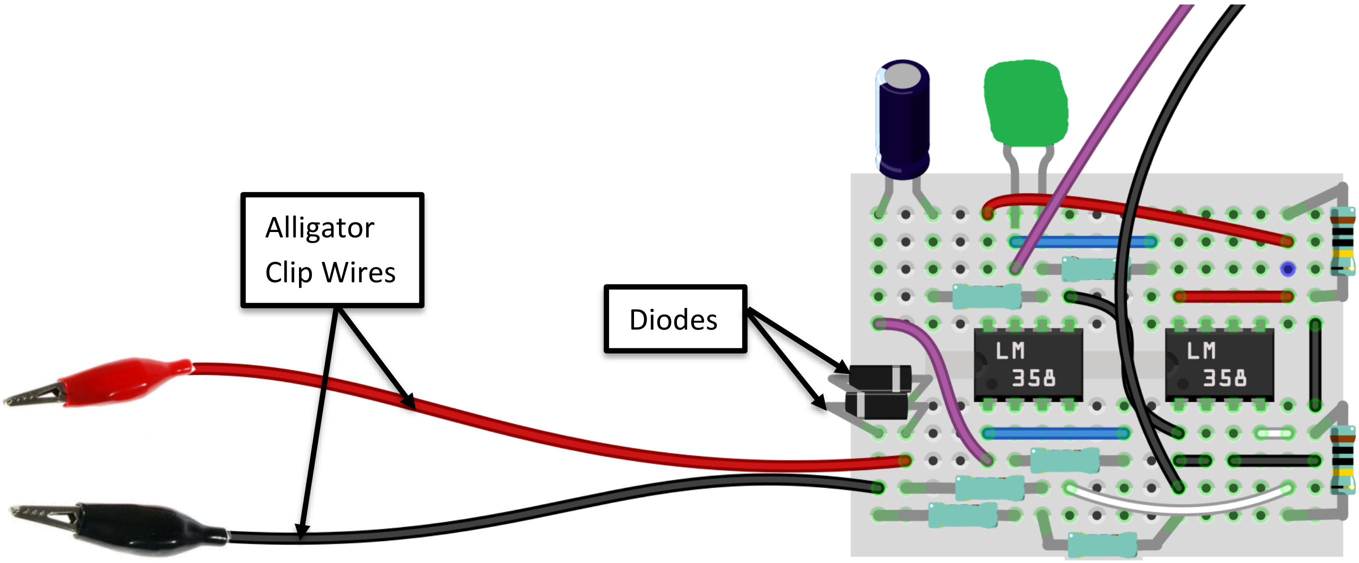
Step 6: Connect the two LM358's together as shown below. The rightmost one provides the ground for the second one, so you'll connect pin 1 of the right one to pin 5 of the left one, as shown below.



Step 7: You're ECG circuit is nearly complete! Next you'll add long wires to be connected to your audio jack. One of these must be connected to ground (pin 1 of the first LM358 chip) and the second wire must be connected to pin 6 of the second LM358. This is shown in the image below.

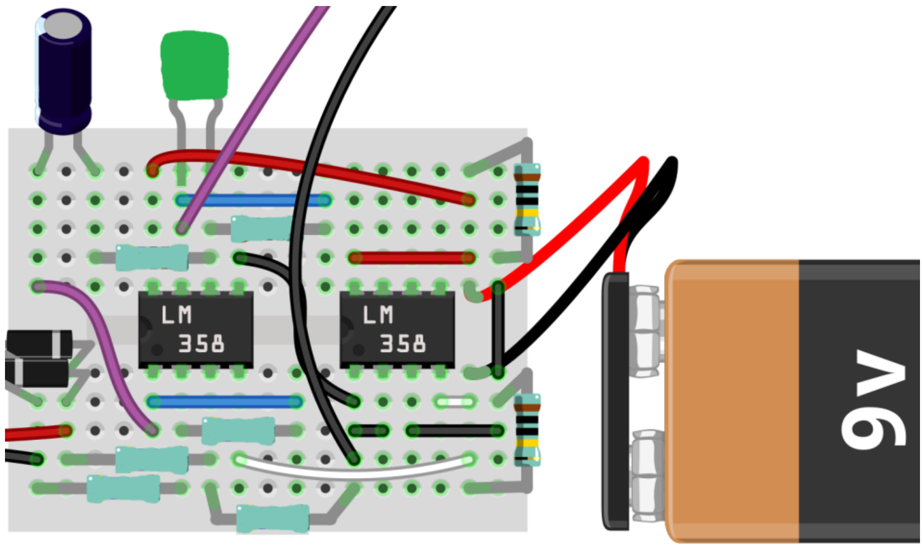


Step 8: Next we'll connect the input wires and 2 diodes to our circuit. The diodes are important because they protect the user from too much voltage. If a voltage spike is detected, they will allow current to flow through them rather than through the user. The grey bar on one end tells you the polarity, make sure that they are each going a different direction. For inputs, we'll connect two long alligator-clip wires to the circuit as shown below. These will be connected to electrode pads you can stick to your forearms.



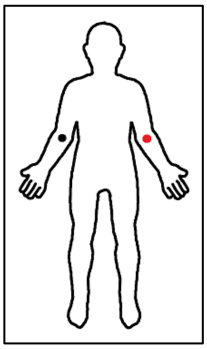
Step 9: Next, have a presenter check your circuit to ensure that there are no big mistakes. If your circuit seems to be made correctly, they'll have you go on to the next step.

Step 10: To finish off your ECG, you'll connect power to your circuit. To do this press a battery cap onto a 9V battery. Then attach the leads to the two ends of your voltage divider as shown below.

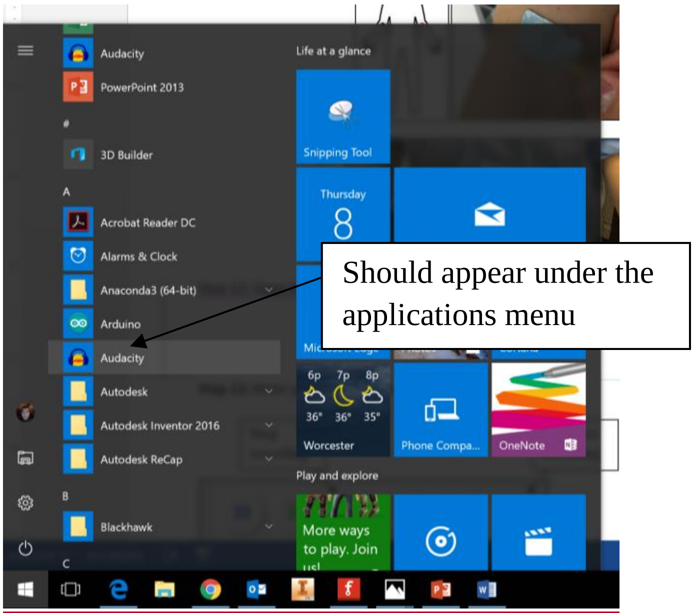


Step 11: Insert audio plug into the USB adapter. The audio connector must be connected into the *microphone* jack, not the headphone jack. And insert the USB adapter into a USB port on your computer.

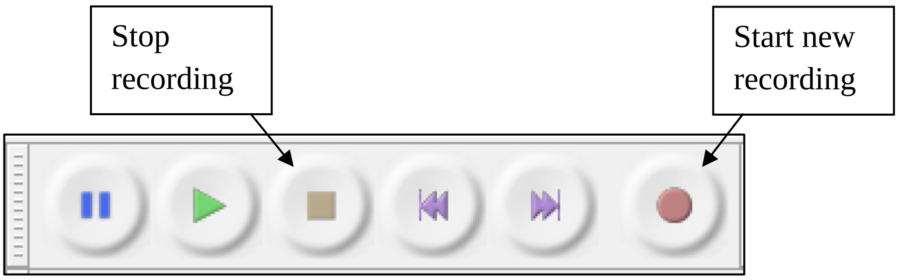
Step 12: Place the electrodes on your forearm as shown in the diagram below, and then attach the alligator clips to the electrodes.



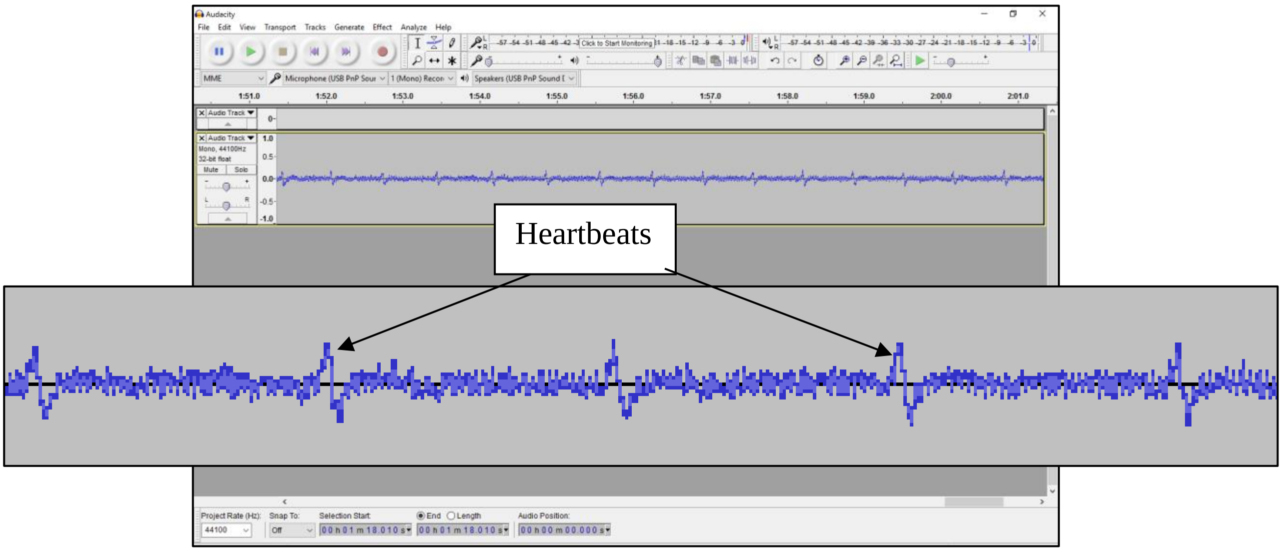
Step 13: Open the Audacity software.



Step 14: Make your first recording on your ECG.

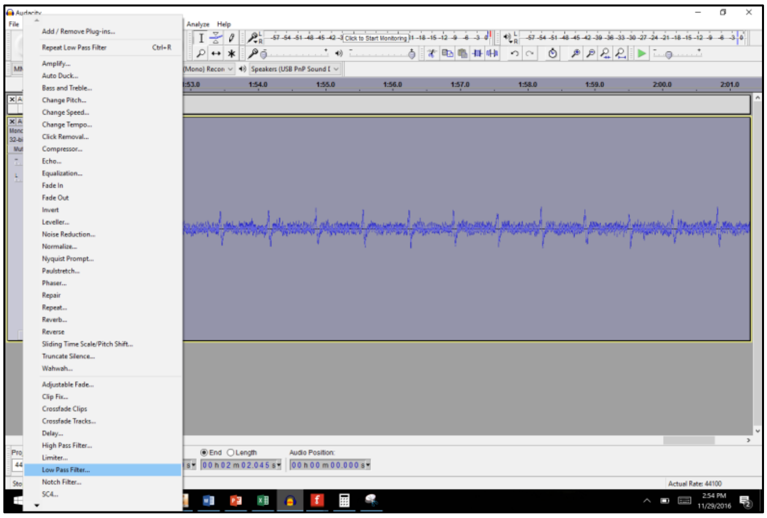


Ideally, you'll see a reading like the one below:

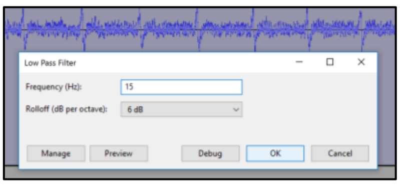


If you do not have a reading like the one above, you may need to do more filtering before you see your heartbeat. After stopping the recording, continue to step 14. If you don't have any noise at all on the output (the fuzzy lines between the heartbeats) then you need to troubleshoot your ECG. Ask a presenter for the troubleshooting guide.

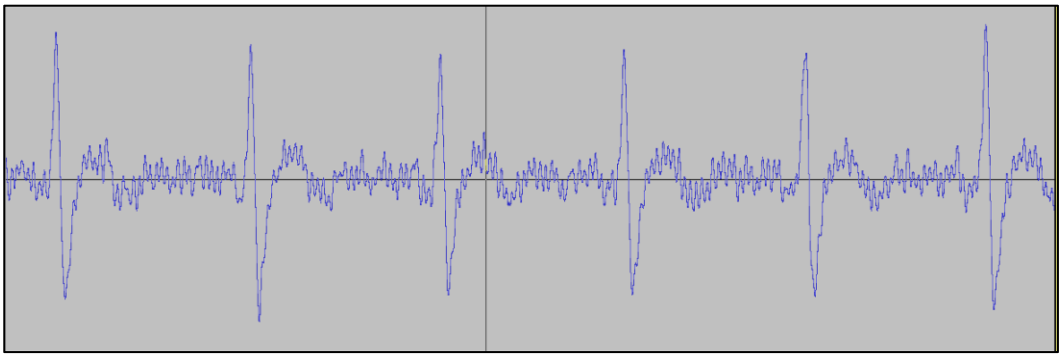
Step 15: It's time to do a little digital filtering of the signal. In Audacity, highlight a portion of your heartbeat that you want to clarify by clicking and dragging the cursor. Hover your cursor over the effects tab at the top of the application menu, then click on "lowpass filter".



The menu that follows allows you to choose a cutoff frequency (frequencies above which signals will be cut). 15Hz works fairly well for the ECG, because most of the electromagnetic noise in the room (radio stations, power outlets, etc.) have a frequency above 15Hz.



You can also “normalize” your signal to make it easier to see. This raises the signal to a “normal” volume. This is under the same effects menu. Leave the default settings and click okay. The final ECG output is shown below.



If you still can’t see your heartbeat, try doing the filtering step and the normalize step several more times. If it still doesn’t work, you may need to use the troubleshooting guide.

Supplemental Materials O

Proposed questions to improve student exit survey

Supplemental Materials O

Proposed questions to improve the Science Bootcamp student exit survey

- How important is math for you to know?
  Very | A little | Not really| Not at all | Not sure
- How important did you think science was for you to know before attending the bootcamp?
  Very | A little | Not really| Not at all | Not sure
- How important do you think science for you to know?
  Very | A little | Not really| Not at all | Not sure
- Is the material from the two-day activity important for you to know? Why or why not?

We recommend that CSIRO continue to use their current preamble.