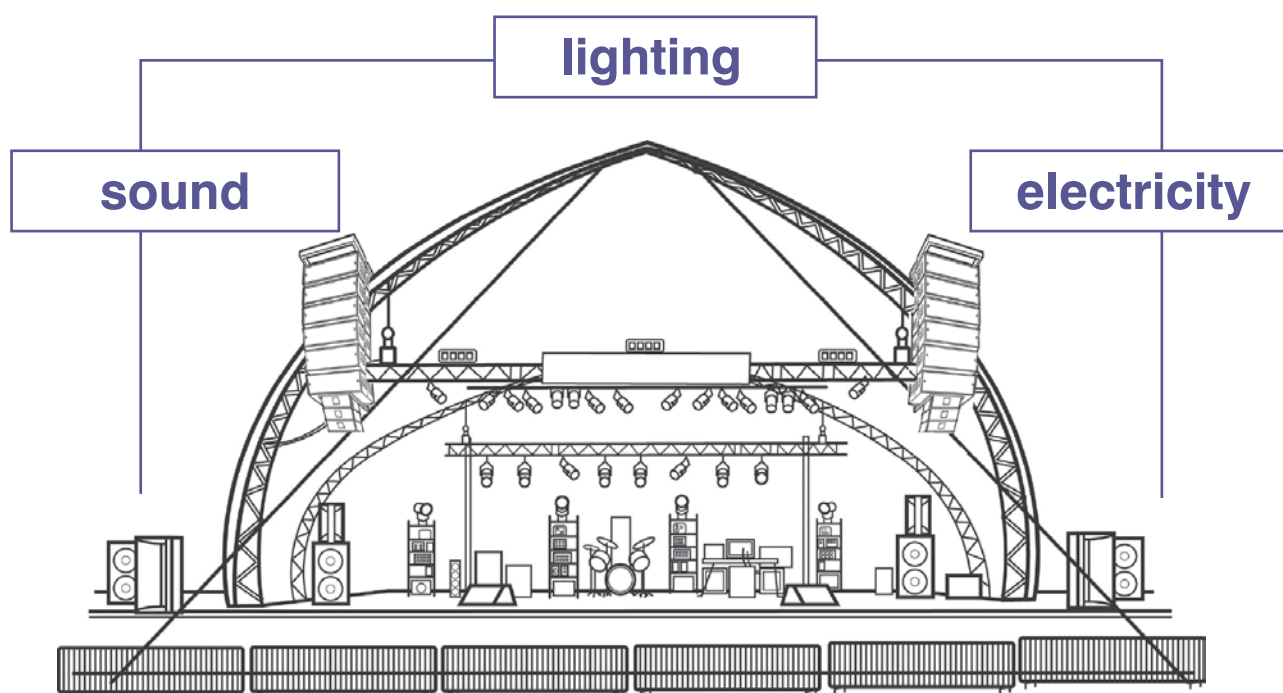


# Physics in Concert



## Teacher notes and student worksheets



Download PowerPoint presentation at [www.iop.org/concert](http://www.iop.org/concert)

Department for  
**Education**



centre for  
**science**  
education

# Contents

	Page
<b>Introduction</b>	<b>1</b>
<b>Teacher notes:</b>	<b>4</b>
Part 1. Physics in context	4
Part 2: Practice your skills	14
Part 3: Planning a concert	16
<b>Student worksheets</b>	<b>20</b>
Worksheet 1	21
Worksheets 2 (A-C)	22
Worksheets 3 (A-C)	28
Worksheets 4 (A-D)	35
Worksheet 5	43
Solutions and mark schemes	47

## Acknowledgements

This activity was developed by the Institute of Physics (IOP) as part of the STEM (science, technology, engineering and maths) Subject Choice and Careers Project (within the STEM Action Programme) funded by the Department for Education.

This activity was written by Taj Bhutta of the IOP and is based on the Ashfield Music Festival activity originally developed by the IOP and CRAC (the Career Development Organisation). Illustrations and design are by Tim Oliver, Phil Treble and Lesley Lee. Futuremorph characters used with permission from The Science Council

### Further information:

For further information about the STEM Careers Project visit the STEM careers collection at National STEM Centre <http://stem.org.uk/cx8h>

For further information about STEM Subject Choice and Careers please contact [stemcareers@shu.ac.uk](mailto:stemcareers@shu.ac.uk)  
T: 0114 225 4870

Centre for Science Education, Sheffield Hallam University, City Campus, Howard Street, Sheffield S1 1WB.

For further information about the Institute of Physics (IOP) please contact  
Tel: +44 (0)20 7470 4800 E-mail: [education@iop.org](mailto:education@iop.org) or visit [www.iop.org/education](http://www.iop.org/education)

Education Department, the Institute of Physics, 76 Portland Place, London W1B 1NT

Incorporated by Royal Charter Registered charity number 293851

## Background

Developed to encourage more students, particularly girls, to consider careers related to physics, this activity is based on the successful Key-Stage 4 activity: *Ashfield Music Festival* <sup>[1]</sup>. Research shows that although girls can greatly benefit from activities which highlight careers and the real-world applications of physics <sup>[2]</sup>, there is a need to provide information about engineering at an earlier age <sup>[3]</sup> and to also make a clearer link between what is learnt in lessons and career opportunities <sup>[4]</sup> in order to encourage greater uptake of physics post-16.

This activity for 13-14 year olds incorporates many of the successful features of *Ashfield Music Festival*; students work in teams, learn about engineering by taking on different roles and learn how physics applies in the context of planning a music event. However, *Physics in Concert* offers greater flexibility in terms of delivery as it does not require recruiting external “expert” help or taking students off-timetable. The two activities can be run independently or used to compliment each other by incorporating *Physics in Concert* at Key-stage 3 and then running *Ashfield Music Festival* at key Stage-4.

<sup>1</sup> Ashfield Music Festival – Institute of Physics 2009  
[www.iop.org/ashfield](http://www.iop.org/ashfield)

<sup>2</sup> Girls in the Physics Classroom: A teacher's guide for action – Institute of Physics 2006  
[www.iop.org/girlsinphysics](http://www.iop.org/girlsinphysics)

<sup>3</sup> Girls' career aspirations - Ofsted April 2011 [Ref 090239]  
[www.educationandemployers.org/media/12161/girls\\_\\_career\\_aspirations.pdf](http://www.educationandemployers.org/media/12161/girls__career_aspirations.pdf)

<sup>4</sup> An investigation into why the UK has the lowest proportion of female engineers in the EU - Engineering UK 2011  
[www.engineeringuk.com/\\_db/\\_documents/Int\\_Gender\\_summary\\_EngineeringUK\\_04\\_11\\_.pdf](http://www.engineeringuk.com/_db/_documents/Int_Gender_summary_EngineeringUK_04_11_.pdf)

## Resources required

- > PowerPoint presentation which is available to download at [www.iop.org/concert](http://www.iop.org/concert)
- > Worksheets (listed below) and included at the end of these notes.

Other (optional) resources for practical demonstrations and activities are given in the relevant section of these notes.

Worksheet	Number required	Worksheet Number
Class-worksheet (optional)	1 per student	1
Practice your skills: Sound engineer	1 per team	2A
Practice your skills: Lighting engineer	1 per team	2B
Practice your skills: Electrical engineer	1 per team	2C
Tasks: Sound engineer	1 per team	3A
Tasks: Lighting engineer	1 per team	3B
Tasks: Electrical engineer	1 per team	3C
Poster: Sound engineer	1 per team	4A
Poster: Lighting engineer	1 per team	4B
Poster: Electrical engineer	1 per team	4C
Poster: Team (optional)	1 per team	4D
Set of Artist request cards	1 per class	5

## Overview

The activity has three parts, (outlined below) and can be run in a number of different ways: off-timetable; over a number of lessons; or as part of an after school science-club. The teacher in charge of the activity should review these notes in order to decide which approach is best and how much time to allocate to each part of the activity.

For parts 2 and 3 of the activity, students should be put in to groups of **three** in order for students to take on different roles. If student numbers are not divisible by three, two teams of four can be created with some students sharing the role of (for example) lighting engineer. The minimum number of students that the activity can be run with is three, and the maximum is thirty (although this can be scaled up to a whole year group, if a number of teachers run it in parallel).

### Part 1: Physics in context

The first part of the activity is teacher led, and can be run over a number of lessons. The topics covered include:

- > Electromagnets: Microphones and speakers
- > Sound: Pitch/frequency and speed of sound
- > CRO traces: amplitude and frequency
- > Sound-levels
- > Primary and secondary colours
- > Light: Absorption and reflection
- > Electricity generation
- > Heating effect of a current
- > Parallel and Series circuits
- > Electrical power, current and voltage

Part 1 of the activity can be used to either teach the above topics for the first time, or to revise them. If teaching for the first time, the suggested demonstrations/practicals in the following notes can be used to expand each of the topics in to a number of lessons. Alternatively if part 1 of the activity is used for revision, worksheet 1 may prove useful.

### Part 2: Practice your skills

In the second part of the activity students are put in to teams of three and choose one of the three engineering roles; sound, lighting or electrical engineer. Once roles are allocated each team chooses the music artist they want to represent and complete separate worksheets (worksheets 2A, 2B and 2C). If the activity is run over a number of lessons this work can be set as homework (in which case the presentation slides that accompany part 2 should be moved to part 1 of the activity)

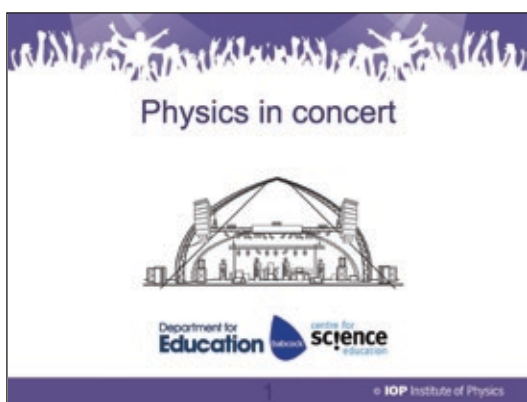
### Part 3: Planning a concert

In the final part of the activity students put what they have learned in to practice. Each team is provided with an "artist request card" (worksheet 5) and complete tasks (worksheets 3A, 3B and 3C) that go with their role and use this information to produce a poster about their plans. Poster worksheets (4A, 4B, 4C and 4D) are provided to assist students. The final part of the activity can be run as a competition.

## Part 1: Physics in context

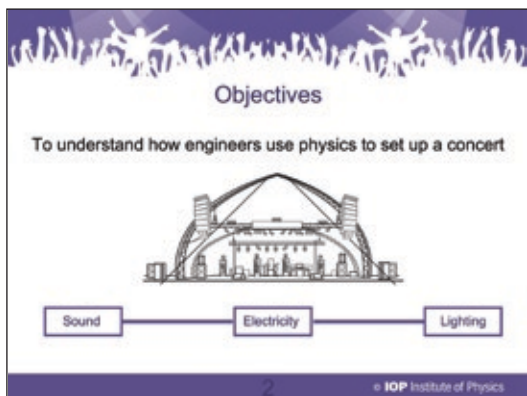
This is a teacher led part of the activity. However there is ample opportunity to expand on the presentation, or add practicals and demonstrations (as indicated below). An optional class worksheet (worksheet 1) is provided for this part of the activity. Slides that relate to this are optional worksheet and denoted by "optional: refers to worksheet 1". Answers to worksheet 1 are provided below at relevant points and also on page 47.

### Introduction



#### Slide 1

Play some music as students arrive. Introduce activity.

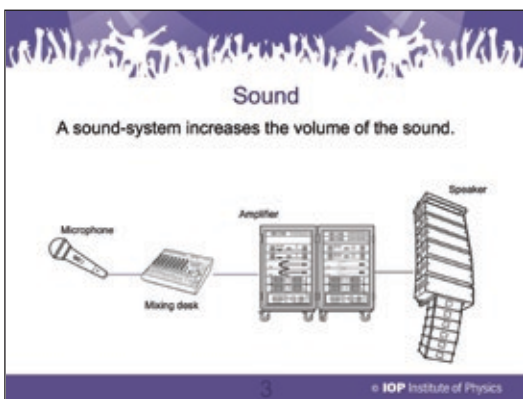


#### Slide 2

Highlight that the areas of physics that are relevant to a concert: sound; electricity; lighting. Explain the term engineer in a general context.

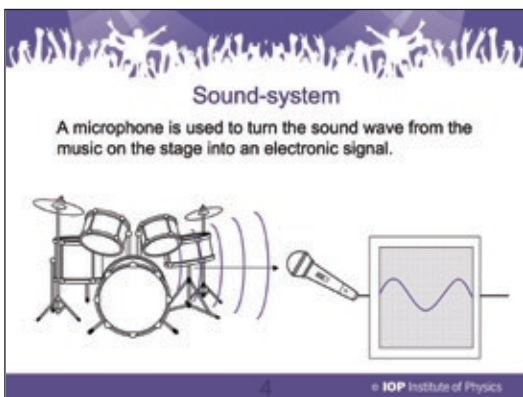
## Sound

Teaching this topic can be greatly enhanced by using a separate sound system (rather than integrated hi-fi) for demonstration purposes. Either a musical instrument or an iPod can be used as a music source to demonstrate that an unamplified sound provides a sound-level that is too low for a concert (for the iPod, earphones can be used as speakers to play the unamplified sound to the class). The source can then be connected to the amplifier-speaker system (via a microphone for the musical instrument) to demonstrate how the sound-level can be increased by first converting the sound in to an electrical signal, amplifying and then converting back to sound. Details of additional demonstrations related to CRO traces, amplitude, frequency and the principles of a moving coil speaker are included in the notes below.



### Slide 3

Introduce components of a sound system and explain them in context of home stereo or iPod dock.

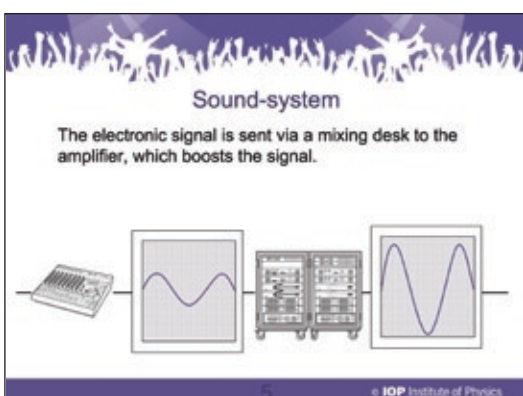


### Slide 4

Explain that to amplify a sound it first needs to be turned in to an electronic signal.

### Suggested demonstration/activity:

A microphone connected to CRO to demonstrate conversion of a sound wave into a CRO trace [tuning fork or human voice can be used as source]



### Slide 5

Use the term *amplitude* to explain how signal has increased in strength.





## Slide 6

Explain how an electrical signal can be converted into motion (in order to generate sound) using an electromagnet and permanent magnet.

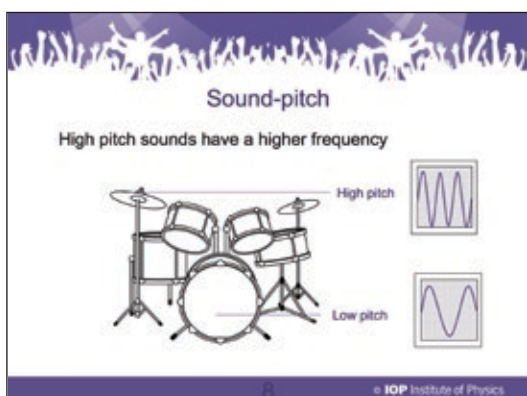
### Suggested demonstration/activity:

Electromagnet connected to a power supply used to repel and attract (by reversing current through the electromagnet) to demonstrate the principle of a moving coil speaker. [www.practicalphysics.org/go/Experiment\\_336.html](http://www.practicalphysics.org/go/Experiment_336.html)



## Slide 7

Link pitch to how "quickly" object vibrates/frequency



## Slide 8

Explain difference in traces for high and low frequency CRO traces

### Suggested demonstration/activity:

Show different frequency traces on a CRO using a signal generator [www.practicalphysics.org/go/Experiment\\_652.html](http://www.practicalphysics.org/go/Experiment_652.html)

OR

A microphone connected to CRO to demonstrate trace for high and low pitch sounds (different tuning forks can be used as sources) [www.practicalphysics.org/go/Experiment\\_654](http://www.practicalphysics.org/go/Experiment_654)



**Q1**

Signals for three different sound waves are shown below.

(i) which signal is from the loudest sound?  
 (ii) which signal is from the highest pitch sound?

© IOP Institute of Physics

## Slide 9 (optional: refers to worksheet 1)

Discuss question-1 and ask students to answer

### Answers:

(i) A      (ii) B

**Sound levels**

- Sound levels are measured in decibels (dB)

Sound level (dB)	Example (if you were nearby)
130	Small explosion
120	Plane at take-off
110	Pneumatic drill
100	Car horn
90	Listening to iPod at full volume
80	Vacuum cleaner
70	Hair dryer
60	Noisy classroom
50	Flushing toilet

Safe noise exposure	
Hours	Sound Level (dB)
8	85
4	90
1	100
1/4	110
0	120

120 dB or above can lead to instant hearing damage

© IOP Institute of Physics

## Slide 10

Discuss sound-levels and exposure times.

**Sound-speed**

Sound travels to the audience at a speed of 330 m/s

Speed = distance ÷ time

© IOP Institute of Physics

## Slide 11

Remind students of relationship for speed.

**Note:** The sound engineers will need to use this relationship to calculate time-delays for satellite speakers in part 3 of the activity (refer to worksheets 3A and 4A).

**Sound at a concert**

**Q2** The speed of sound is 330 m/s. How long it takes sound to travel 40 m?

© IOP Institute of Physics

## Slide 12 (optional: refers to worksheet 1)

Discuss question-2 and ask students to answer.

### Answer:

0.12 seconds

## Lighting

If students have covered “the eye” the topics in this section can be linked to cone cells. A useful video clip that can be used as a starter to this part of the activity can be found at [www.bbc.co.uk/learningzone/clips/242](http://www.bbc.co.uk/learningzone/clips/242)



### Slide 13

Introduce primary colours: red, green and blue (RGB). Explain that these colours are used because all colours can be “simulated” using different levels and combinations of these primary colours.

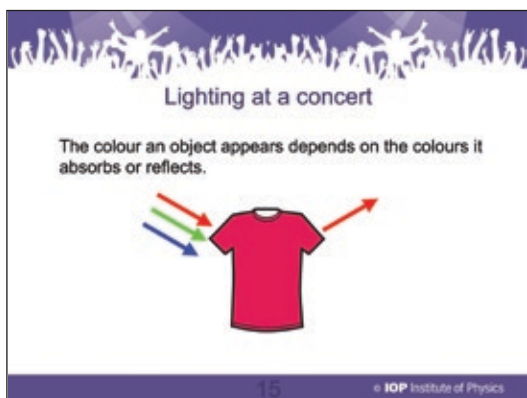


### Slide 14

Explain secondary colours and RGB colour mixing.

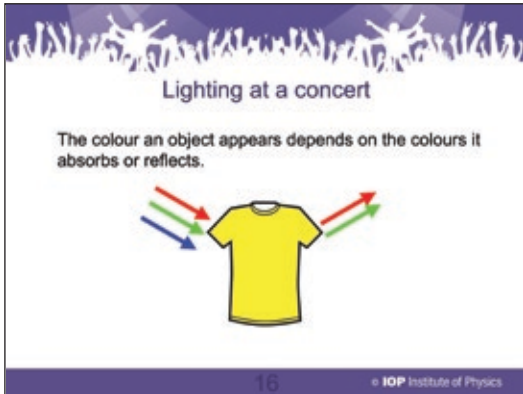
## Suggested demonstration/activity:

Additive colour mixing demonstration using RGB sources [www.practicalphysics.org/go/Experiment\\_721.html](http://www.practicalphysics.org/go/Experiment_721.html)



### Slide 15

Explain how absorption and reflection of primary colours can give an object a red appearance under white light



**Slide 16**

Explain why an object has a yellow appearance under white light and extend this to general appearance of objects under different combinations of RGB lighting

**Suggested demonstration/activity:**

A useful app for students to try can be found at: [www.ltscotland.org.uk/resources/s/light/lighting.asp?strReferringChannel=resources&strReferringPageID=tcm:4-248284-64](http://www.ltscotland.org.uk/resources/s/light/lighting.asp?strReferringChannel=resources&strReferringPageID=tcm:4-248284-64)



**Slide 17 (optional: refers to worksheet 1)**

Introduce question-3 to the students.



**Slide 18**

Explain that under all three lights the costume appears as it would do under white light.



## Slide 19

Explain the appearance of the costume under blue light (and link this to the first completed line of the table in question-3 if using worksheet 1). Ask students to consider the appearance of the costume under green light.



## Slide 20

After discussion reveal the answer. Ask students to consider the appearance of the costume under red light (and fill in their answer in to the table if using worksheet 1)



## Slide 21

After discussion reveal the answer. Ask students to correct their answer if necessary, and to consider costume under red and green lighting combined (and complete the next line of the table if using worksheet 1)



## Slide 22

After discussion reveal the answer. Ask students to correct their answer if necessary.



**Slide 23**

Highlight the fact that costume designers and lighting engineers need an understanding of how objects appear under different colours.

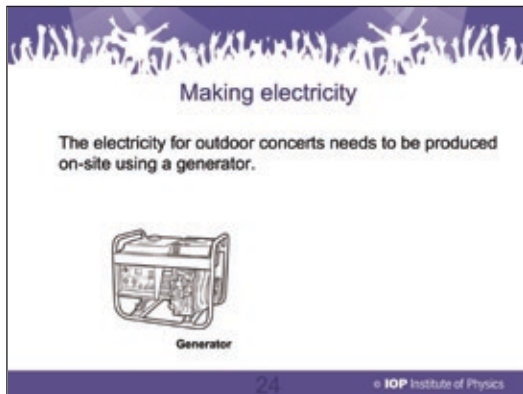


**Slide 24**

Review colour mixing

## Electricity

If students have covered large-scale energy generation the topics in this section can also be linked to electricity generation in coal-fired and nuclear power stations. There is the opportunity to link to other topics such as fuses and parallel circuits.

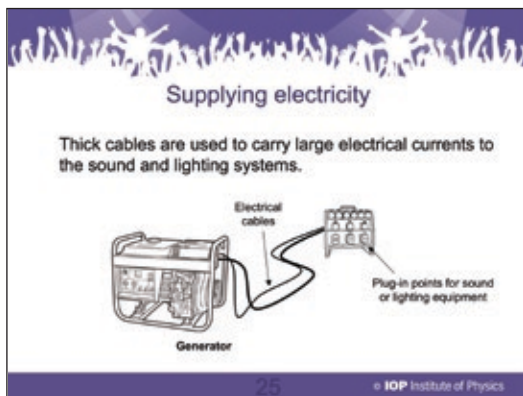


### Slide 25

Explain the principles of a generator and why fuel (diesel) is needed.

### Suggested demonstration/activity:

A bicycle dynamo to demonstrate principle of a generator [www.practicalphysics.org/go/Experiment\\_345](http://www.practicalphysics.org/go/Experiment_345)

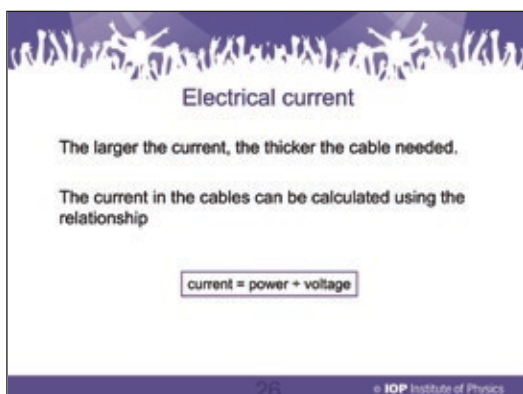


### Slide 26

Explain the heating effect of a current and explain why large currents require thick cables.

### Suggested demonstration/activity:

Heating effect of current [www.practicalphysics.org/go/Experiment\\_277](http://www.practicalphysics.org/go/Experiment_277)

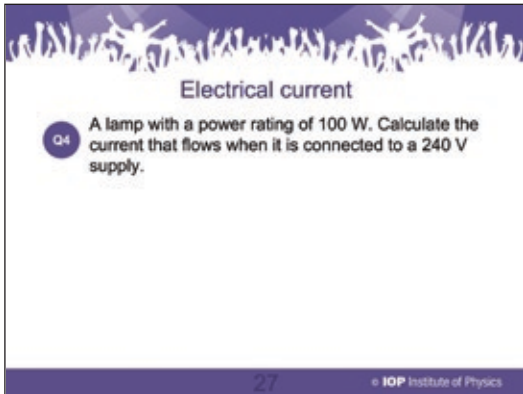


### Slide 27

Explain the heating effect of a current and explain why large currents require thick cables.

**Suggested demonstration/activity:**

Ask students to consider power consumption/current for low power and high power devices and show students cables from e.g. a mobile phone charger and kettle.

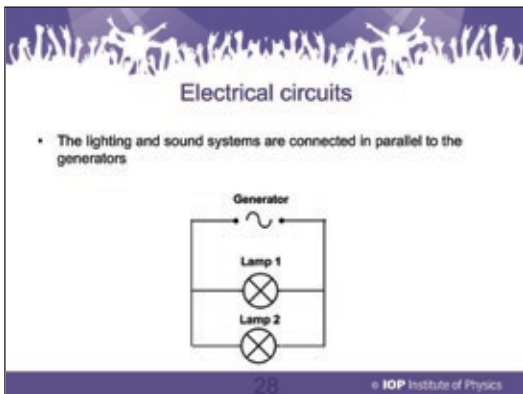


**Slide 28 (optional: refers to worksheet 1)**

Ask students to complete question-4

**Answer:**

0.42 A

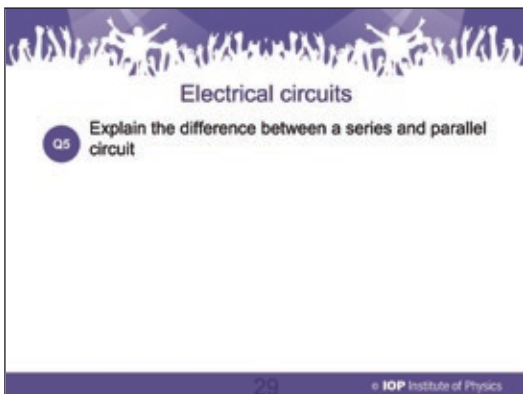


**Slide 29**

Introduce circuit symbol for a generator and review parallel circuits.

**Suggested demonstration/activity:**

There is the opportunity to set up series and parallel circuits and explain why most circuits are wired in parallel.



**Slide 30 (optional: refers to worksheet 1)**

Students discuss and complete question-5

**Answer:**

*In a series circuit there is only one route for the current to flow around the circuit. In a parallel circuit there is more than one route.*



## Part 2: Practice your skills

Organise students in to teams of three before starting this section of the activity.


### Resources required:

- > 1 set of practice sheets per team of three students [i.e. 1 x worksheet 2A, 1 x worksheet 2B and 1 x worksheet 2C per team]
- > Access to the internet
- > Colouring pens/pencils [including all primary and secondary colours]


### Presentation

**Engineers at a concert**


- Different engineers are responsible for the sound, lighting and electrical systems.



Sound Engineer



Electrical Engineer



Lighting Engineer

30 © IOP Institute of Physics

### Slide 31

Remind students of the term *engineer* and explain that there are various types of engineers involved in setting up a concert.

**Choose an artist**

- Each person in your team will take on a different role
- But first you must choose the artist or group you will represent...



2 minutes


31 © IOP Institute of Physics

### Slide 32

Ask the team to discuss which artist they would like to plan a concert for, and to come to a decision within the allotted time.

**Select your role by looking at the key skills:**

<b>1</b> Creative Analytical Visual	<b>2</b> Analytical Using diagrams Numerical	<b>3</b> Spatially aware Analytical Numerical
--	---	--

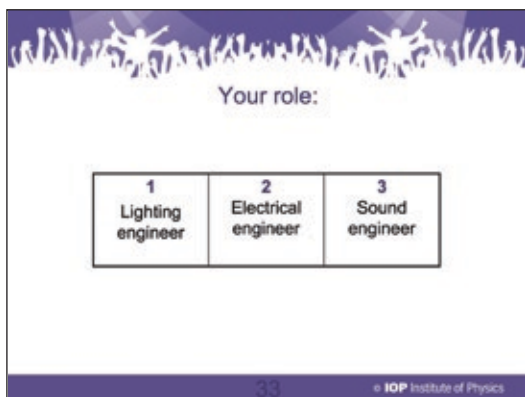


2 minutes

32 © IOP Institute of Physics

### Slide 33

Ask team members to select a role (by choosing a number) after considering the skills.



### Slide 34

Reveal their role and ask them to make a note of it.



### Slide 35

Explain that students will be expected to complete separate worksheets to practice skills related to their role. **Hand out practice sheets [Worksheets 2A-C]**

## Practice your skills

The remainder of this part of the activity (completion of worksheets 2A-2C) can be either done in class or set as homework. Separate worksheets for each team member allow students to practice the skills that go with their role and are intended to give students ownership of the role, however this does mean that some thought needs to be given to how this work is marked and/or corrected.

If the practice sheets are set as homework, the teacher running the activity could return marked work to the students in the next lesson and the students could be put in to three groups according to the role they have taken on (i.e. all sound engineers together) and students help each other make corrections. Alternatively, if the practice sheets are completed in class the teacher could bring up a third of the students at a time (e.g all sound engineers) and run through their work while other students get on with their tasks in the next part of the activity (planning a concert). Marks schemes and answers to practice sheets are provided at the end of these notes.

## Internet access

Internet access is required for the last question (question 5) on all *practise your skills* worksheets.. This question asks asks students to research jobs that require an A-level in physics to develop their understanding of the range of careers from physics (beyond the role they have selected as part of the activity). If internet access is not available then question 5 should be set as homework (it is not required for completion of the next part of the activity and so can also be set after completion of the whole activity if required).

## Part 3: Planning a concert

### Resources required:

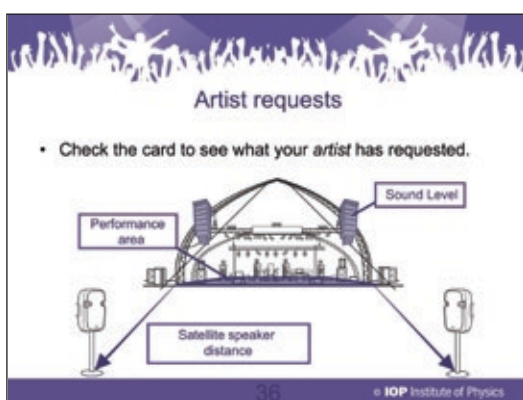
- > 1 set of artist request cards per team [i.e. cut out cards from Worksheet 5]
- > 1 set of task sheets per team [i.e. 1 x worksheet 3A, 3B and 3C per team]
- > 1 set of poster sheets per team [i.e. 1 x worksheet 4A, 4B and 4C per team]
- > Optional: 1 copy of worksheet 4D per team
- > 1 set of resources to produce a poster per team (e.g.):
  - A2 backing paper
  - Glue
  - Pens, paper
  - Colouring pens/pencils [including primary and secondary colours]
  - Additional paper

### Slides



### Slide 36

Explain that students will be using the skills they practiced in the previous part of the activity to plan a concert for their chosen artist and produce a poster about their plans.



### Slide 37

Explain that the artists they represent have certain requirements. **Hand out one artist request card per team.**

## Sound engineers

To do	✓
➤ Use the equipment list to work out which equipment needs power. Let the electrical engineer know.	
➤ Use the equipment list to work out the total power needed for the sound system.	
➤ Work out the time it takes the sound from the main speakers to reach the satellite speakers (the time delay).	
➤ Complete the sound poster sheet and work with your teammates to complete a poster about your plans.	

38 © IOP Institute of Physics

### Slide 38

Hand out one set of task sheets and poster sheets per team. Briefly explain what the sound engineers in each team need to do.

## Lighting engineers

To do	✓
➤ Work out how many lighting-bars are needed for the performance area, let the electrical engineer know.	
➤ Work out the power required for the lighting system (lighting bars and desk).	
➤ Follow instructions on the lighting poster sheet and produce coloured sketches of your artist's costumes.	
➤ Work with your teammates to complete a poster about your plans (remember to include images you have of the artist).	

39 © IOP Institute of Physics

### Slide 39

Briefly explain what the lighting engineers in each team need to do.

## Electrical engineers

To do	✓
➤ Work with the sound engineer to complete the sound system circuit diagram on the poster sheet.	
➤ Work with the lighting engineer to determine the number of lights. Use this information to complete the lighting system circuit diagram on the poster sheet.	
➤ Work with the sound and lighting engineers to determine the power needed for the sound and lighting systems.	
➤ Calculate the total current in the lighting and sound circuits (use the total power for each circuit to do this). Record this information on the poster sheet.	
➤ Use the current to work out the thickness of the cables that should be used in the sound and lighting systems to connect to the generators.	

40 © IOP Institute of Physics

### Slide 40

Briefly explain what the electrical engineers in each team need to do.

Emphasise that the students are part of a team and that they must share information and work together to complete the poster, if they are waiting on information or have completed their tasks they can help their team mates to complete their tasks or work on other aspects of the poster.

Details of the expected answers for each team and role are shown on the next page.

## Artist requests

Remind the students that each team has differing requests from the artists (as shown below) and so they will have different answers to the tasks.

	Information provided on artist request card		
Card	Sound level	Satellite speaker distance	Performance area
1	98 dB	40 m	8 m X 3.5 m
2	99 dB	45 m	8 m X 3.5 m
3	98.5 dB	48 m	7 m X 3 m
4	98 dB	45 m	7 m X 3 m
5	99 dB	40 m	6 m X 4 m
6	98.5 dB	50 m	6 m X 4 m
7	98 dB	50 m	8 m X 3 m
8	99 dB	43 m	8 m X 3 m
9	98.5 dB	43 m	7 m X 4 m
10	98 dB	48 m	7 m X 4 m

## Tasks

The students should initially be given minimal help on completing their tasks and told to read through all the information provided carefully. The values that the lighting, sound and electrical engineers should obtain (depending on the team's artist request card) are tabulated below. Information on how the following values are obtained from the artist request information can be found at the end of these notes in the *solutions and mark schemes* section.

	Lighting		Sound		Electrical	
Card	No of Lighting-bars	Power required (W)	Time delay (S)	Power required (W)	Lighting circuit current (A)	Sound circuit current (A)
1	7	11,500	0.12	29,000	48	121
2	7	11,500	0.14	33,500	48	140
3	6	10,000	0.15	31,500	42	131
4	6	10,000	0.14	29,000	42	121
5	6	10,000	0.12	33,500	42	140
6	6	10,000	0.15	31,500	42	131
7	6	10,000	0.15	29,000	42	121
8	6	10,000	0.13	33,500	42	140
9	7	11,500	0.13	31,500	48	131
10	7	11,500	0.15	29,000	48	121

### Posters

Once completed, the poster sheets can be cut out and stuck to the backing paper as part of the team poster. The lighting engineers should add any images they have of their artists (which they researched as part of the *practice your skills* sheet) and the whole team should add any further details that they want to. Students can also use the (optional) team poster sheet (worksheet 4D) which depicts the stage if they want to add further details or design a backdrop for their artists.

Prizes can be awarded for the best poster.

# Worksheets

Student worksheets for the activity are on the following pages.

Double-sided worksheets (e.g worksheet 2A) are presented on a two page spread.

<b>Worksheet</b>	<b>Number required</b>	<b>Worksheet Number</b>
Class-worksheet (optional)	1 per student	1
Practice your skills: Sound engineer	1 per team	2A
Practice your skills: Lighting engineer	1 per team	2B
Practice your skills: Electrical engineer	1 per team	2C
Tasks: Sound engineer	1 per team	3A
Tasks: Lighting engineer	1 per team	3B
Tasks: Electrical engineer	1 per team	3C
Poster: Sound engineer	1 per team	4A
Poster: Lighting engineer	1 per team	4B
Poster: Electrical engineer	1 per team	4C
Poster: Team (optional)	1 per team	4D
Set of Artist request cards	1 per class	5

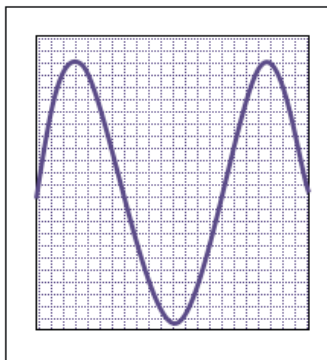




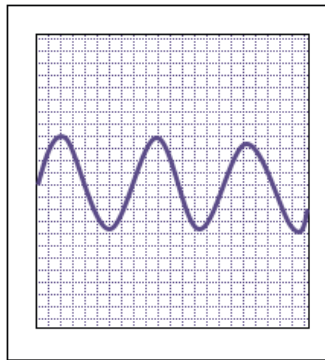
1. Signals for three different sound waves are shown below.

- (i) Which signal is from the loudest sound?
- (ii) Which signal is from the highest pitch sound?

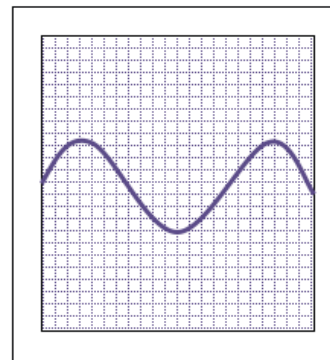
**A**



**B**



**C**



2. The speed of sound is 330 m/s. How long it takes sound to travel 40 m?  
(Give your answer to two decimal places)

3. An artist on stage wears a red T-shirt with a yellow star motif. She also wears blue trousers.

Copy and complete the table showing how her costume appears under different colour lighting [the first one has been done for you]

Lighting	Appearance of:		
	Red T-shirt	Yellow Motif	Blue trousers
Blue	Black	Black	Blue
Green			
Red			
Red & Green			
Red, Green & Blue			

4. A lamp with a power rating of 100 W. Calculate the current that flows when it is connected to a 240 V supply. (Give your answer to two decimal places).

5. Explain the difference between a series and parallel circuit.

# Practice your skills

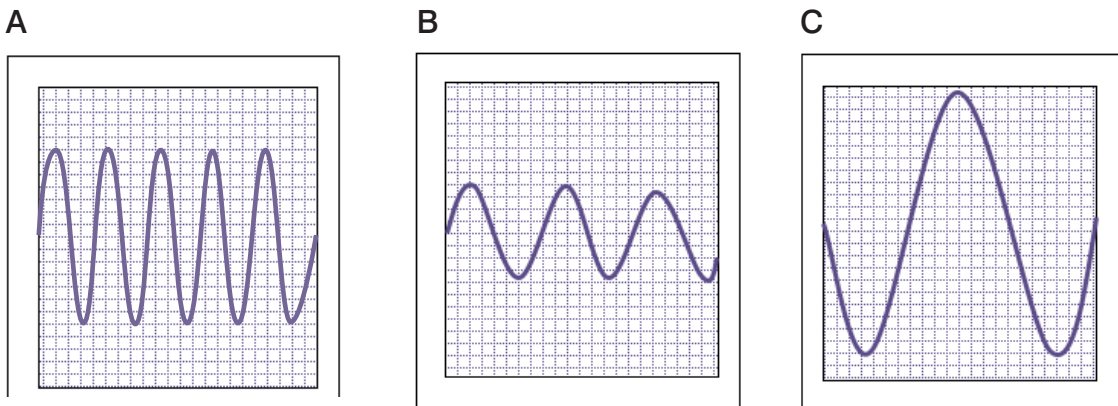
## Sound engineer



1. The devices that make up a sound system at a concert are listed below. Copy the diagram and match each device to its description (one has been done for you).

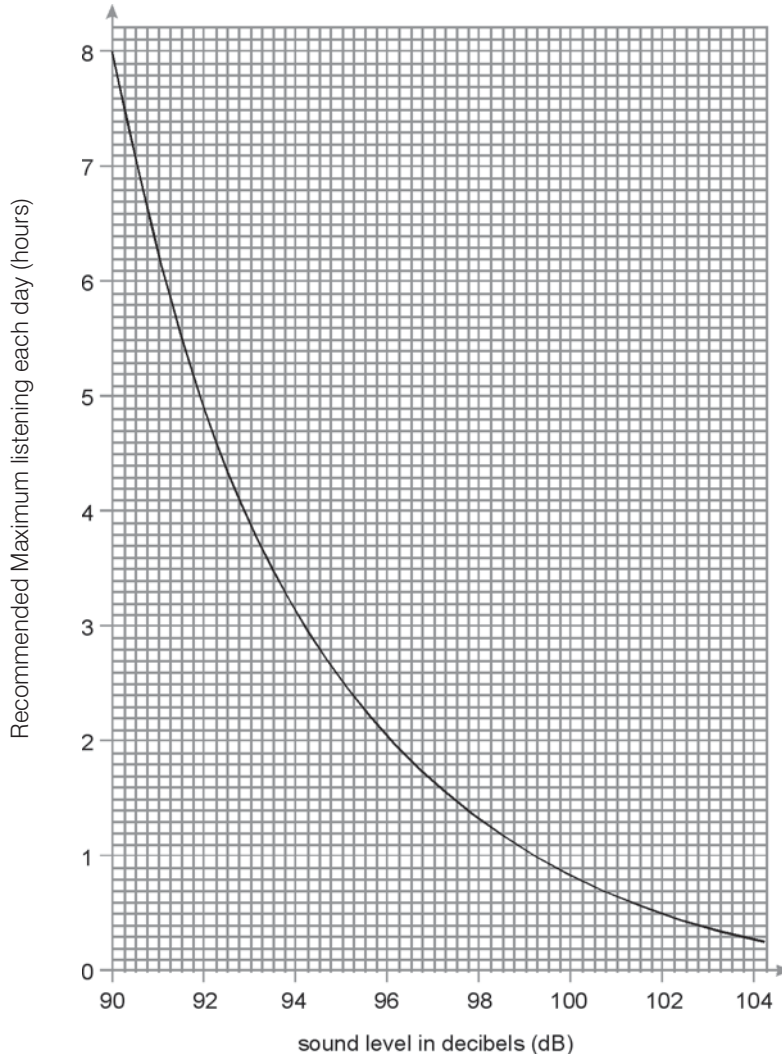
<b>Microphone</b>	A device that controls the relative levels that the audience hears
<b>Mixing-desk</b>	A device that turns electricity in to sound
<b>Amplifier</b>	A device that boosts an electrical signal
<b>Speaker</b>	A device that turns sound in to electricity

2. The traces for different sound signals are shown below.



- (a) Which trace represents the highest pitch sound?  
(b) Which trace represents the lowest pitch sound?  
(c) Which trace represents the loudest sound?
3. Sound travels through the air at a speed of 330 m/s
- (a) Work out the time it takes for sound to travel 100 m from the stage at a concert.  
(b) How far will sound travel in 1 minute?

4. Sound levels are measured in decibels (dB). The graph shows the recommended maximum times people should listen to sounds of different levels. At longer times there could be serious damage to hearing.



- (a) What is the maximum time each day for listening to an iPod at 96 dB?
- (b) A sound engineer works for five hours at a concert.
- What should the maximum sound level be so that her hearing is not damaged?
  - The sound-level in front of the main speaker at the concert is 100 dB. What could a sound engineer do to protect her hearing?
5. A sound engineer is just one example of a person that uses physics in their job. Use the web-sites below to research either a man or a woman that has studied A-level physics. Write a paragraph about what they do and how they use physics.

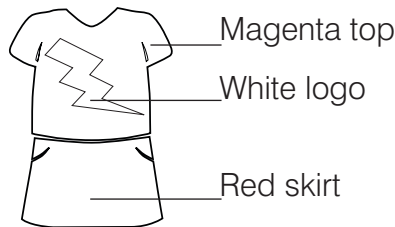
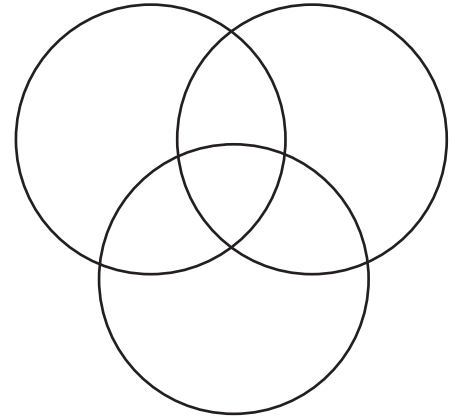
[www.physics.org/careers](http://www.physics.org/careers) | [www.futuremorph.org](http://www.futuremorph.org) | [www.epsrc.ac.uk/noise/makers/](http://www.epsrc.ac.uk/noise/makers/)



# Practice your skills



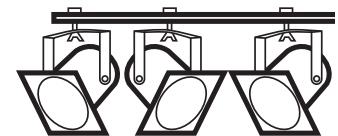
1. The primary colours of light are red, green and blue. Copy and colour in the diagram on the right to show the colours that are produced when primary colours are mixed.
2. The backing singers at a concert wear the outfit shown below; a magenta T-shirt with a white logo and a red skirt.



A lighting engineer switches on the lights in the following order - blue, red and then green at the opening of a concert. Copy and complete the table to show how the costume will appear.

Lighting	Appearance of:		
	Magenta top	White logo	Red skirt
Blue	Black	Blue	Black
Blue & Red			
Red, Green & Blue			

3. The lights at a concert come in bars. If each lighting-bar can light up an area of  $4 \text{ m}^2$  of a stage, how many lighting bars are needed to light up the whole of a stage that is 7m wide and 4m long? (show all your working).

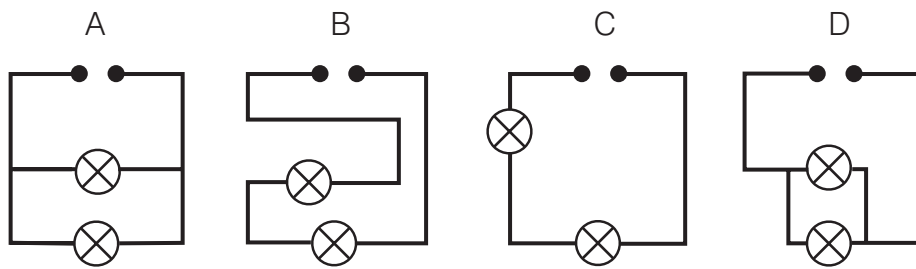


4. Use the Internet or magazines to research the type of costumes your team's chosen artist wears. Print up or cut out images of your artists.
5. A lighting engineer is just one example of a person that uses physics in their job. Use the web-sites below to research either a man or a woman that has studied A-level physics. Write a paragraph about what they do and how they use physics.

[www.physics.org/careers](http://www.physics.org/careers) | [www.futuremorph.org](http://www.futuremorph.org) | [www.epsrc.ac.uk/noise/makers/](http://www.epsrc.ac.uk/noise/makers/)

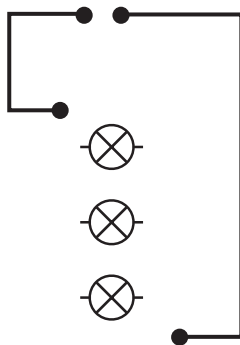


1. The following circuits contain two lamps. Copy the diagrams and then answer the questions below.

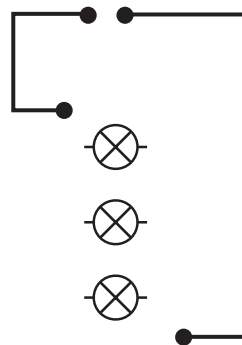


- (a) Which two circuits are series circuit?  
 (b) Which other circuit is the same as circuit A?  
 (c) Which other circuit is the same as circuit B?
2. The following diagrams show *incomplete* circuit diagrams for two circuits, both of which containing three lamps. Copy and complete the circuit diagrams to show the lamps in (a) series and (b) parallel

(a) Series

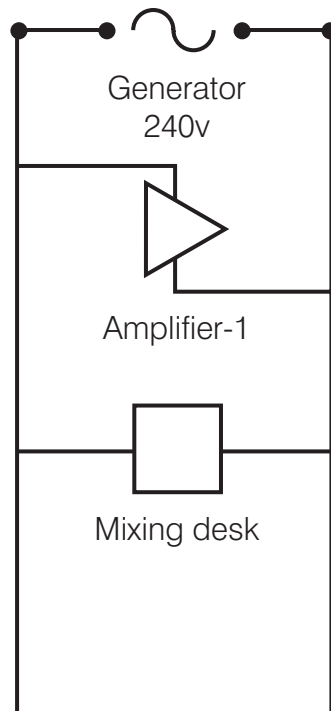


(b) Parallel



3. For the following questions remember to give the unit with your answers
- (a) Calculate the **power** used by a mixing desk in which a current of 4 A flows when it is connected to a 240 V supply.
- (b) An amplifier has a power rating of 1200 W. Calculate the **current** that flows when it is connected to in to a 240 V supply.
- (c) A sound system at a concert needs 24,000 W of power. If the current in the connecting wire is 100 A, what is the **voltage** of the generator used to supply the electricity?
- (d) Which of the above (mixing desk, amplifier or sound system) needs the thickest cables in order to connect them to the power supply safely? Explain your answer.

4. The circuit below shows an amplifier connected to a 240 V generator and a mixing desk.



- (a) Copy the diagram and add another amplifier (Amplifier-2) to the circuit. Amplifier-2 should be in parallel to the mixing desk.
- (b) The power used by Amplifier-1 is 5000 W; the mixing desk is 1000 W; and Amplifier-2 is 3000 W.
- (i) What is the **total** power used by the circuit.
- (iii) Use the total power to calculate the current carried by the wires connected to the generator.
5. An electrical engineer is just one example of a person that uses physics in their job. Use the web-sites below to research either a man or a woman that has studied A-level physics. Write a paragraph about what they do and how they use physics.

[www.physics.org/careers](http://www.physics.org/careers) | [www.futuremorph.org](http://www.futuremorph.org) | [www.epsrc.ac.uk/noise/makers/](http://www.epsrc.ac.uk/noise/makers/)

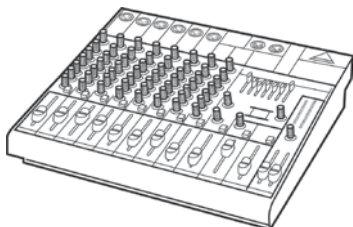




**Use information from the equipment list below and artist request-card to complete your tasks.**

To do	✓
> Use the equipment list to work out which equipment needs power. Let the electrical engineer know.	
> Use the equipment list to work out the total power needed for the sound system.	
> Work out the time it takes the sound from the main speakers to reach the satellite speakers (the time-delay)	
> Complete the sound poster sheet and work with your teammates to complete a poster about your plans.	

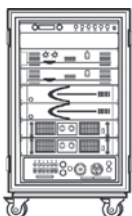
## Equipment list



### Mixing Desk

This mixing desk controls relative levels of the instruments and the time delay for the satellite speakers in the audience area.

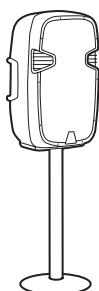
**Power required:** 500 W



### Satellite amplifier

This small amplifier boosts the signal for the satellite-speakers in the audience area.

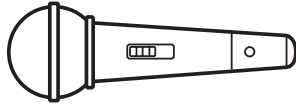
**Power required:** 2000 W



### Satellite-speakers

Satellite speakers are placed in the audience area to boost the (high-frequency) sound. The signal to these must be delayed so that the sound produced by these speakers reaches the audience at the same time as that produced by the stage speakers. These speakers are powered by an amplifier and do not require power from the generators.

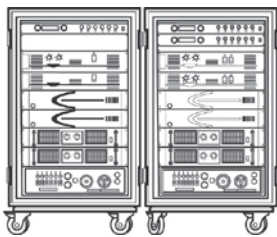
**Power required:** 0 W



## Microphones

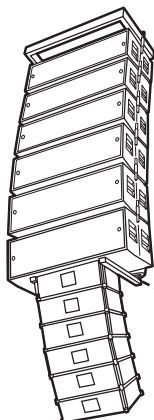
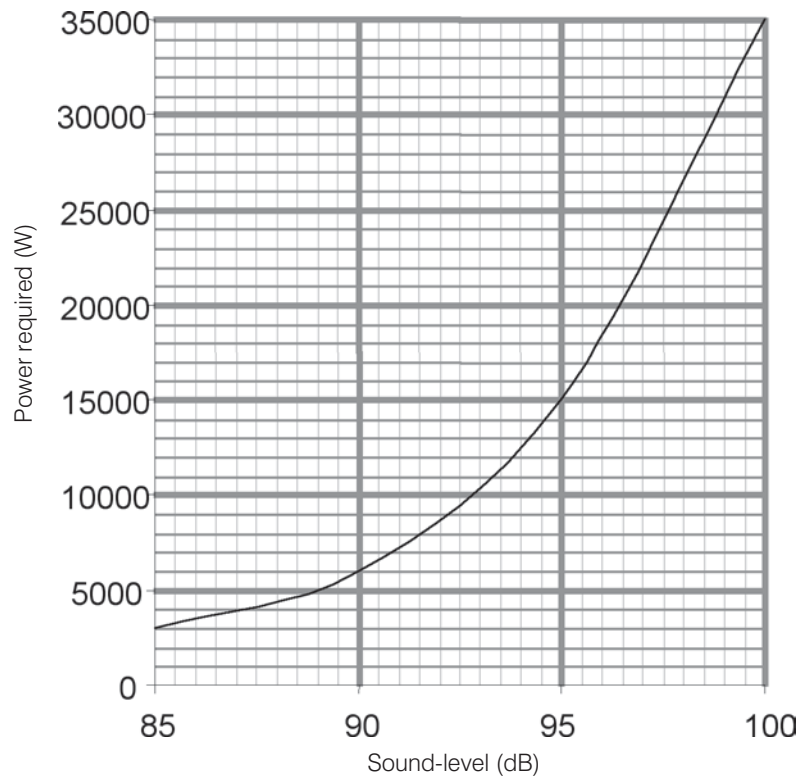
Microphones convert the sound on stage in to electrical signals. These microphones are battery powered and do not require power from the generators

Power required: 0 W



## Stage amplifier

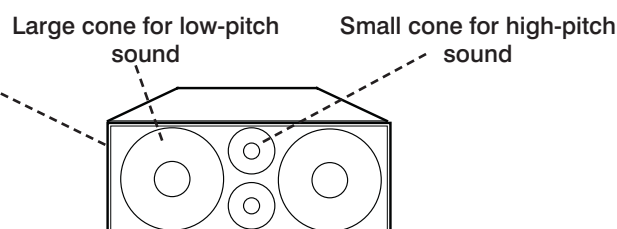
This large amplifier boosts the signal for the stage speakers. **The power required by the amplifier depends on the sound-level** that you want the main-stage speakers to play at.



## Stage-speaker array

These speakers are mounted on the main stage.

Electric circuits inside the speakers split the signal in to high and low frequencies and send these to different parts of the speaker. These speakers are powered by an amplifier and do not require power from the generators



Power required: 0 W

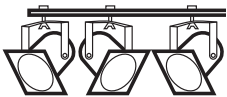




Use information from the equipment list below and artist-request-card to complete the tasks.

To do	✓
> Work out how many lighting-bars are needed for the performance area, let the electrical engineer know.	
> Work out the power required for the lighting system (lighting-bars and desk)	
> Follow instructions on the lighting poster sheet and produce coloured sketches of your artist's costumes.	
> Work with your teammates to complete a poster about your plans (remember to include images you have of the artists)	

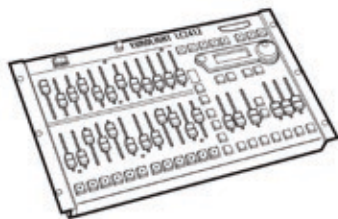
## Equipment list



### Lighting-bar

Each lighting bar consists of three primary coloured lights (red, green and blue). **Each bar can illuminate an area of 4 m<sup>2</sup> of the stage.**

Power required: 1500 W



### Lighting-desk

A lighting desk is needed to control the lighting. The lighting desk can be used to switch on different coloured lights.

Power required: 1000 W

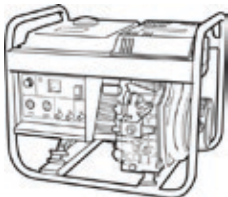




**Use information from the equipment list below and artist request card to complete your tasks.**

To do	✓
> Work with the sound engineer to complete the sound-system circuit diagram on the poster sheet.	
> Work with the lighting engineer to determine the number of lights. Use this information to complete the lighting-system circuit diagram on the poster sheet.	
> Work with the sound and lighting engineers to determine the power needed for the sound and lighting systems.	
> Calculate the total current in the lighting and sound circuits (use the total power for each circuit to do this). Record this information on the poster sheet	
> Use the current to work out the thickness of the cables that should be used in the sound and lighting systems to connect to the generators	

## Equipment list



### Generator

The generators supply electricity at 240 V. Two are needed; one for lighting and the other for the sound-system.



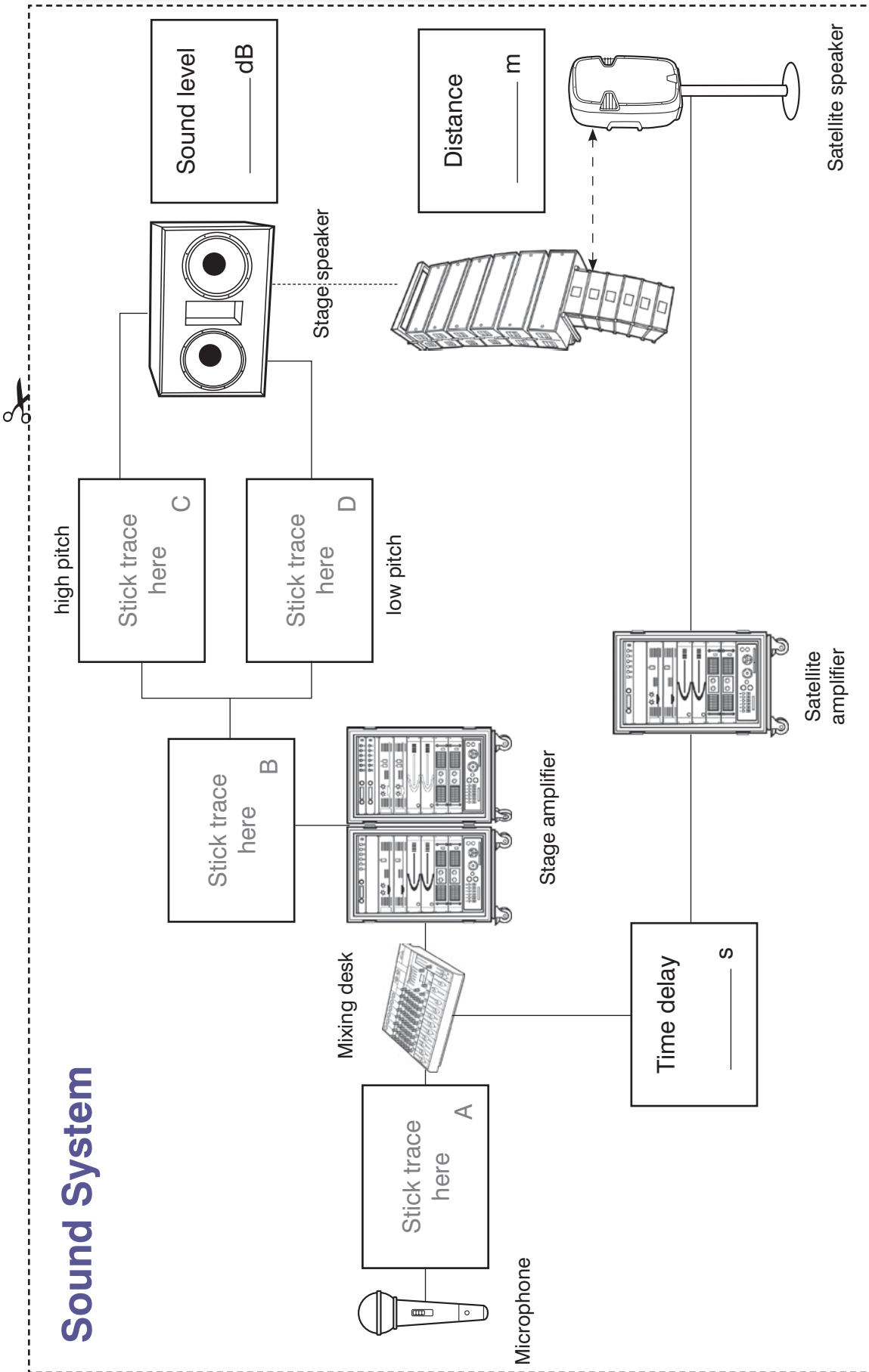
### Cables

Thick cables are needed to connect the generators to the lighting and sound-systems. You should select the smallest diameter cables that can carry the current safely.

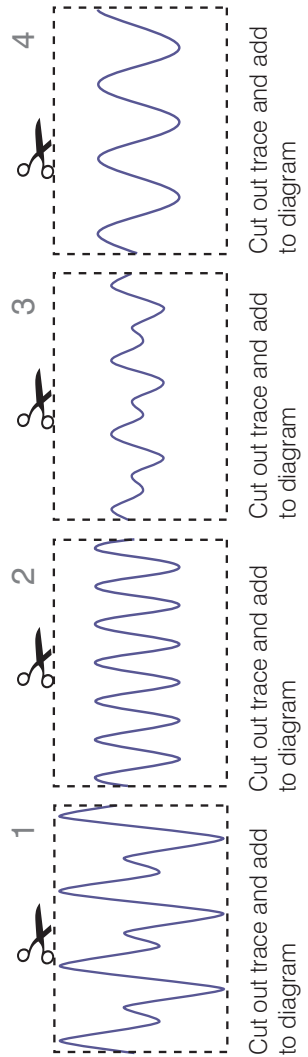
Cable diameter	Maximum safe current
2.5 mm	16 A
4 mm	32 A
16 mm	63 A
35 mm	125 A
70 mm	400 A





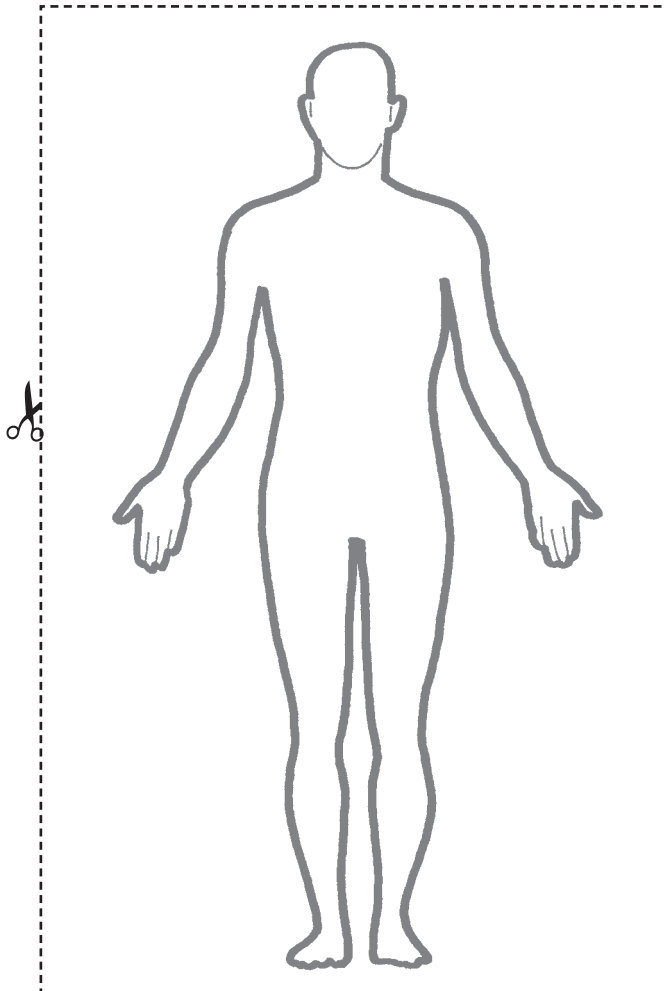


**Instructions:** Complete the diagram above for the sound system by (1) writing in the sound-level, distance (between stage and satellite speakers) and time delay AND (2) cutting out the traces and sticking them in the appropriate boxes. Once you have done this, cut along the dotted line and add the diagram to your team's poster.





**Instructions:** Design and draw colour sketches of your artist's costume. Include a table to show how your costume will appear under different lighting that you will use at the opening of the concert (you may use the templates below or draw your own table and diagram). Once completed cut out the diagram and table and add it to your teams's poster.

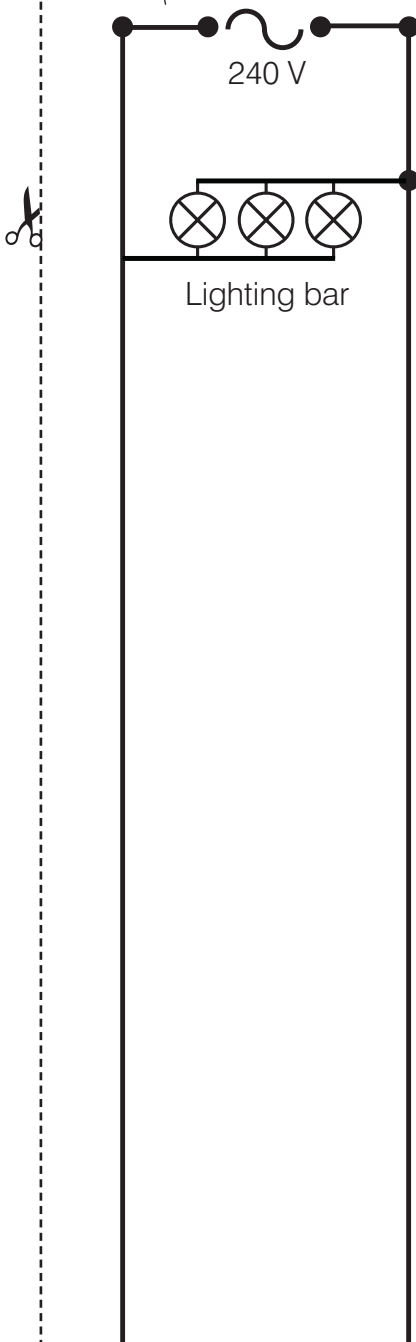


Lighting	Appearance of:		
	Top (e.g T-shirt)	Bottom (e.g skirt)	Design (e.g logo on T-shirt)



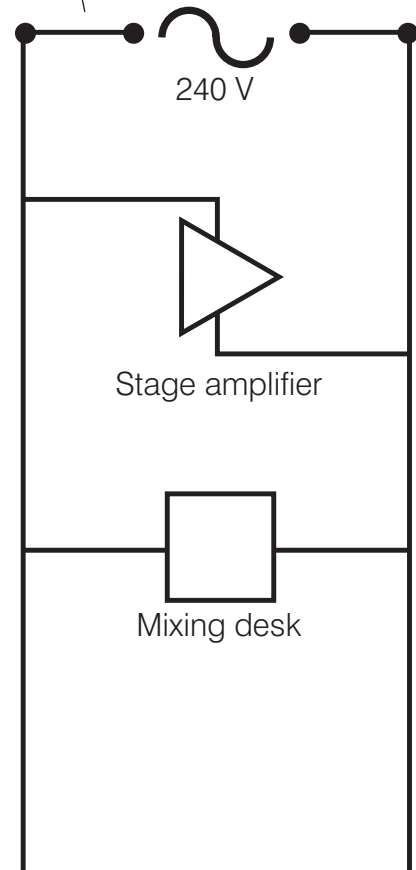
## Lighting circuit

Current =    A  
Cable diameter =    mm



## Sound circuit

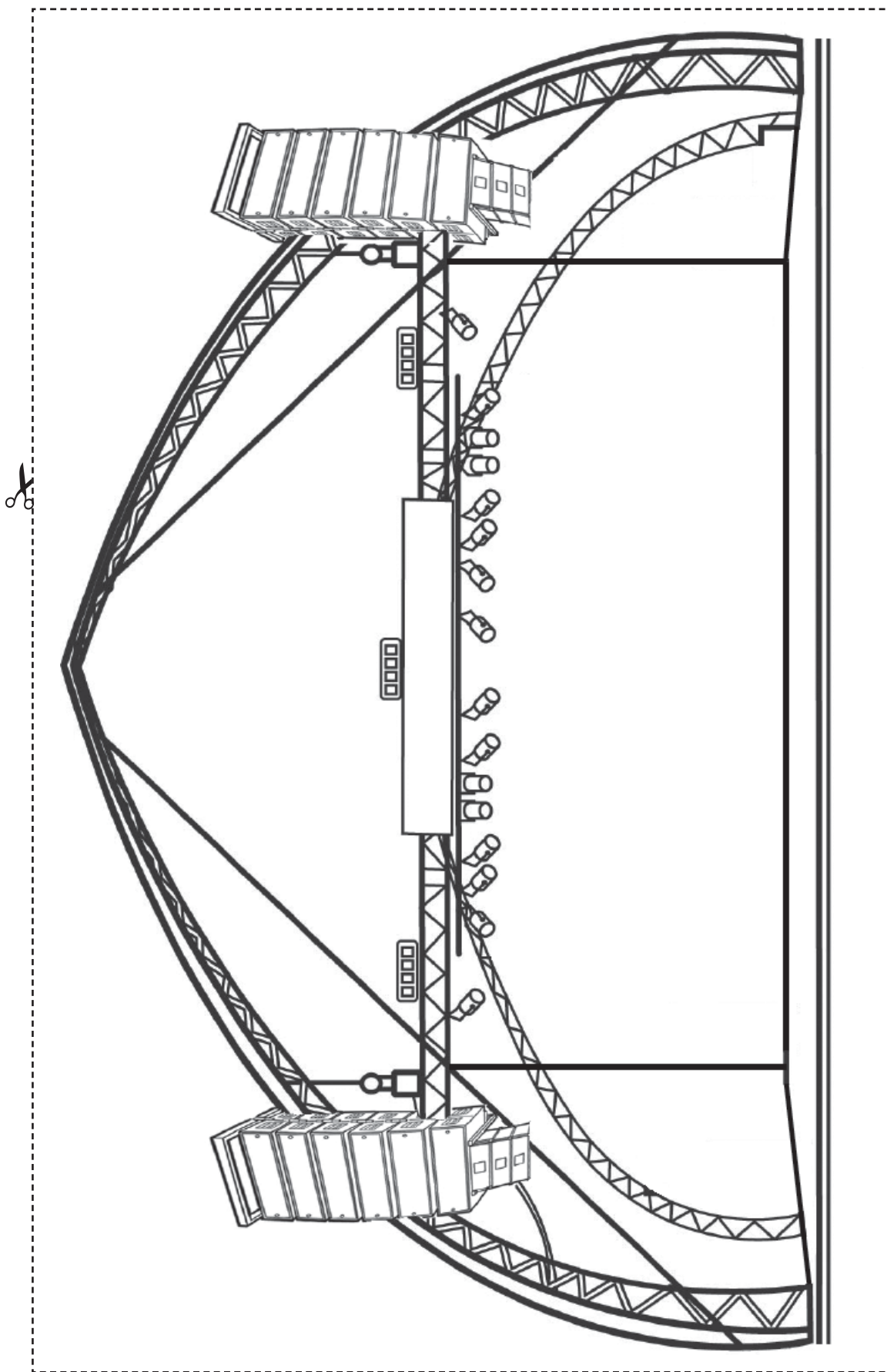
Current =    A  
Cable diameter =    mm



### Instructions:

After completing the circuit diagrams, cut them out along the dotted line and add to them to your team's poster





**Instructions:** You may include extra information about the stage set-up on this sheet if you wish. Once you have done this, cut along the dotted line and add the diagram to your team's poster.





The artists at the concert have requested the following:

Sound level = 98 dB

Satellite-speakers placed at 40 m from the main stage

Performance area of 8 m x 3.5 m

card 1

The artists at the concert have requested the following:

Sound level = 99 dB

Satellite-speakers placed at 40 m from the main stage

Performance area of 6 m x 4 m

card 5

The artists at the concert have requested the following:

Sound level = 99 dB

Satellite-speakers placed at 45 m from the main stage

Performance area of 8 m x 3.5 m

card 2

The artists at the concert have requested the following:

Sound level = 98.5 dB

Satellite-speakers placed at 50 m from the main stage

Performance area of 6 m x 4 m

card 6

The artists at the concert have requested the following:

Sound level = 98.5 dB

Satellite-speakers placed at 48 m from the main stage

Performance area of 7 m x 3 m

card 3

The artists at the concert have requested the following:

Sound level = 98 dB

Satellite-speakers placed at 50 m from the main stage

Performance area of 8 m x 3 m

card 7



**The artists at the concert have requested the following:**

**Sound level = 98 dB**

**Satellite-speakers placed at 45 m from the main stage**

**Performance area of 7 m x 3 m**

card 4

**The artists at the concert have requested the following:**

**Sound level = 99 dB**

**Satellite-speakers placed at 43 m from the main stage**

**Performance area of 8 m x 3 m**

card 8

**The artists at the concert have requested the following:**

**Sound level = 98.5 dB**

**Satellite-speakers placed at 43 m from the main stage**

**Performance area of 7 m x 4 m**

card 9

**The artists at the concert have requested the following:**

**Sound level = 98 dB**

**Satellite-speakers placed at 48 m from the main stage**

**Performance area of 7 m x 4 m**

card 10



# Solutions and mark schemes

## Class Worksheet

### Worksheet 1 (Optional)

1. (i) A (ii) B
2. 0.12 s
- 3.

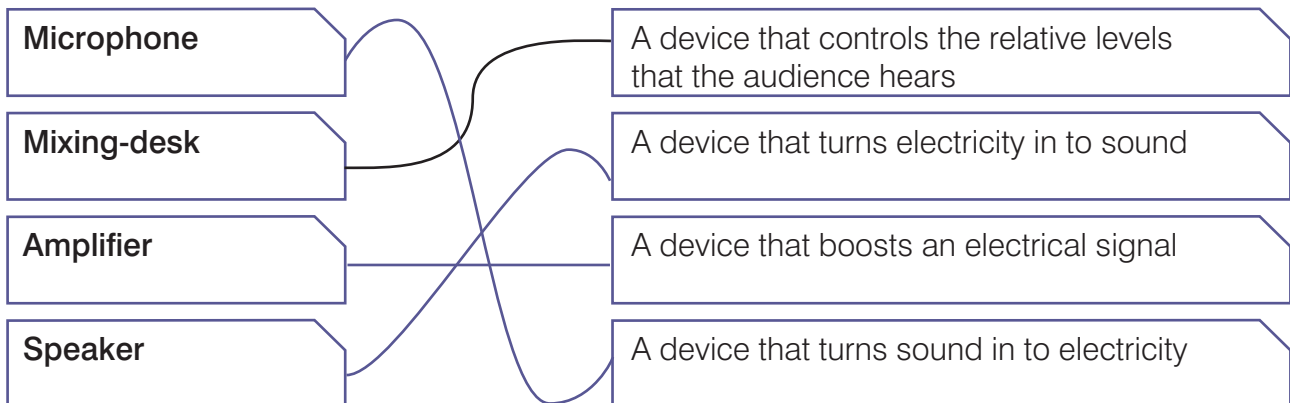
	Appearance of:		
Lighting	Red T-shirt	Yellow Motif	Blue trousers
Blue	Black	Black	Blue
Green	<b>Black</b>	<b>Green</b>	<b>Black</b>
Red	<b>Red</b>	<b>Red</b>	<b>Black</b>
Red & Green	<b>Red</b>	<b>Yellow</b>	<b>Black</b>
Red, Green & Blue	<b>Red</b>	<b>Yellow</b>	<b>Blue</b>

4. 0.42 A
5. In a series circuit there is only one route for the current to flow around the circuit. In a parallel circuit there is more than one route.

# Practice your skills

## Worksheet 2 A (Sound engineer)

1.



1 mark for one correct answer, 2 marks for all correct

2 marks maximum

2.

- (a) The highest pitch sound is **A**
- (b) The lowest pitch sound is **C**
- (c) The loudest sound is **C**

1 mark for each correct answer

3 marks maximum

3.

- (a)  $\text{time} = \text{distance}/\text{speed} = 100 \text{ m} / 330 \text{ m/s} = 0.30 \text{ s}$
- (b)  $\text{distance} = \text{speed} \times \text{time} = 330 \text{ m/s} \times 60 \text{ s} = 19,800 \text{ m}$

1 mark for each correct answer, 1 mark for converting minutes to seconds in part (b)

3 marks maximum

4.

- (a) The maximum safe time for an iPod at 96 dB is **2 hours**
- (b) (i) The maximum safe sound level for five hours is **92 dB**  
(ii) The sound engineer could either wear **ear-protection** [accept limit the amount of time they spend next to the main speaker if a suitable time given].

1 mark for each correct answer

3 marks maximum

5.

Marks awarded for

- o Job title
- o Brief description of what person does
- o Indication of physics knowledge or skills required

1 mark for each

### Model answer

Katherine is an ice scientist. She uses satellites to monitor the ice at the Earth's poles to understand changes in our climate. She uses physics in her job because she needs to understand how to process data from satellites and radar equipment.

[[www.physics.org/careers](http://www.physics.org/careers)]

3 marks maximum

Total: 15 marks maximum



**Worksheet 2 B (Lighting engineer)**

**1.**

1 mark for correct primary colours (red, green and blue), 1 mark for correct secondary colours.

**2 marks maximum**

**2.**

Appearance of:			
Lighting	Magenta top	White design	Red skirt
Blue	Blue	Blue	Black
Blue & Red	<b>magenta</b>	<b>magenta</b>	<b>red</b>
Red, Green & Blue	<b>magenta</b>	<b>white</b>	<b>red</b>

1 mark for any correct answer, 1 mark for correct first row, 1 mark for correct second row.

**3 marks maximum**

**3.**

- > Area of stage = 7 m X 4 m = 28 m<sup>2</sup>
- > Number of lighting-bars needed = 28 m<sup>2</sup>/ 4 m<sup>2</sup> = 5.25
- > So 6 lighting-bars are needed

1 mark for any evidence of understanding correct method, 1 mark each for correct answers (allow error carried forward, only award last mark if answer is whole number)

**4 marks maximum**

**4.** Evidence of research in to teams chosen artist

Picture of artist in costume at a concert

1 mark for each

**2 marks maximum**

**5.** Marks awarded for

**See page 47 for model answer**

- o Job title
- o Brief description of what person does
- o Indication of physics knowledge or skills required

1 mark for each

**3 marks maximum**

**Total: 15 marks maximum**

## Worksheet 2 C (Electrical engineer)

1.

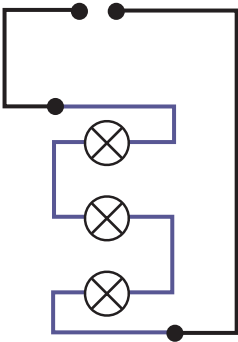
- (a) Circuit **B and C** are series circuits
- (b) Circuit **D** is the same as circuit A
- (c) Circuit **C** is the same as circuit B

1 mark for each correct answer

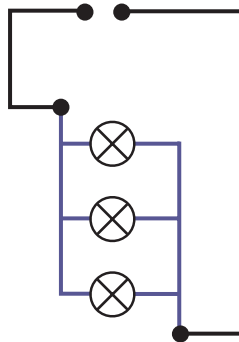
3 marks maximum

2.

(a) Series



(b) Parallel



1 mark for each correctly completed circuit

2 marks maximum

3.

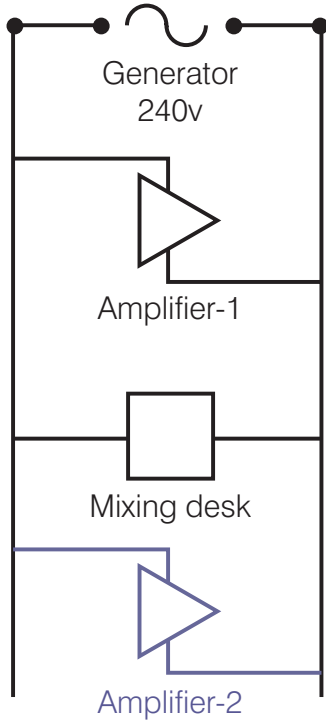
- (a) Power = current x voltage = 4 A X 240 V = **960 W**
- (b) Current = power/voltage = 1200 W / 240 V = **5 A**
- (c) Voltage = power/current = 24,000 W/ 100 A = **240 V**
- (d) The sound system needs the largest cable as this needs the largest current and so needs the **lowest resistance wire to reduce heating of the wire.**

1 mark for each correct numerical answer, 1 mark for ALL units being correct,  
1 mark for correct explanation to (d).

4 marks maximum

4.

(a)



(b) (i) Total power = 5000 W + 1000 W + 3000 W = **9000 W**

(ii) Current = power/voltage = 9000 W/240 W = **38 A**

1 mark for amplifier-2 drawn correctly, 1 mark for each correct numerical answer  
(allow error carried forward)

3 marks maximum

5.

Marks awarded for

- o Job title
- o Brief description of what person does
- o Indication of physics knowledge or skills required

1 mark for each

3 marks maximum

Total: 15 marks maximum

# Tasks and Posters

## Worksheet 3 A (sound engineer tasks)

The sound engineer is expected to use the sound level on the artist request card to determine the power required for the stage amplifier (using the graph on worksheet 3A) and hence the total sound system power. They will also need to determine the time delay required for the satellite speakers. **Using the information on card 1 as an example**

*Power required:*

Mixing desk = 500 W  
Satellite amplifier = 2000 W  
Stage amplifier = 26,500 W

Using 98 dB sound-level and reading off the graph on worksheet 3A

Hence, total power required for sound = 29,000 W

This information should be passed on to the electrical engineer

*Time delay for satellite speakers:*

Time delay = Distance/speed = 40 m / 330 m/s = 0.12 s

## Worksheet 4 A (sound poster sheet)

The sound engineers should record the time delay and other information from the artist request card on their poster sheet and also cut out traces 1-4 and stick them in the appropriate boxes:

**Box A = trace 3** [a sound of two mixed frequencies]

**Box B = trace 1** [an amplified version of trace 3]

**Box C = trace 2** [the high frequency part of trace 1]

**Box D = trace 4** [the low frequency part of trace 1]

## Worksheet 3 B (lighting engineer tasks)

By using the performance area information provided on the artist request card the lighting engineer is expected to calculate the number of lights and total power required. Again using the information on card 1 as an example

*Number of lighting bars needed*

Performance area = 8 m X 3.5 m = 32 m<sup>2</sup>  
Number of lighting-bars required = 32 m<sup>2</sup>/4 m<sup>2</sup> = **7 light-bars**

As indicated on worksheet 3B, each lighting bar illuminates an area of 4 m<sup>2</sup>

*Power required:*

Lighting desk = 1000 W  
Lighting bars = 7 X 1500 W = 10,500 W

Hence, total power required for lighting = **11,500 W**

This information should then be passed on to the electrical engineer.

## Worksheet 4 B (lighting poster sheet)

The lighting engineers are required to design costumes and draw coloured sketches of these. Encourage students to use primary and secondary colours in their designs.

The lighting engineers are also required to explain how their costumes will appear under different lighting (as they have done in worksheet 2 B). Students are free to draw their own tables/diagrams or use the templates provided on worksheet 4B.

If students struggle with this, review slides 13-24 from part 1 of the activity with them.

### Worksheet 3 C (electrical engineer tasks)

The electrical engineer needs to consult with both the sound and lighting engineers to determine the number of components that need to be added to the sound system and lighting circuit diagram on the poster sheet (worksheet 4C). They should conclude that a single amplifier (satellite amplifier) needs to be added to the sound circuit and either five or six lighting-bars need to be added to the lighting circuit diagram (dependent on the information provided on their artist request card). Again using the information on card 1 as an example, a typical calculation would be:

*Cable required for lighting system generator*

Power = 11,500 W

Current = Power/Voltage = 11,500 W/ 240 V = **48 A**

Hence a **16 mm** diameter cable is required

*Cable required for sound system generator*

Power = 29,000 W

Current = Power/Voltage = 29,000 W/ 240 V = 121 A

Hence a **35 mm** diameter cable is required

Information provided by lighting engineer

Using information given on worksheet 3C

### Worksheet 4 C (electrical poster sheet)

The electrical engineers should complete their poster sheet by adding a single amplifier to the sound circuit and appropriate number of lighting-bars to the lighting circuit. They should also record current and cable diameters for each circuit.

Although the current required for the lighting and sound systems vary from team to team, **all lighting systems require a 16 mm diameter cable and sound systems require a 35 mm cable.**

### Worksheet 4D (team poster sheet)

Students may use worksheet 4D (which depicts the stage) if they want to add further details or design a backdrop for their artists.

### Completed posters

The values that should be displayed on the team poster at the end of the activity (dependent on their artist request card) are tabulated. All lighting systems should have 16 mm cables and sound circuits should have 35 mm cables.

Card	Lighting		Sound		Electrical	
	No of Lighting-bars	Power required (W)	Time delay (S)	Power required (W)	Lighting circuit current (A)	Sound circuit current (A)
1	7	11,500	0.12	29,000	48	121
2	7	11,500	0.14	33,500	48	140
3	6	10,000	0.15	31,500	42	131
4	6	10,000	0.14	29,000	42	121
5	6	10,000	0.12	33,500	42	140
6	6	10,000	0.15	31,500	42	131
7	6	10,000	0.15	29,000	42	121
8	6	10,000	0.13	33,500	42	140
9	7	11,500	0.13	31,500	48	131
10	7	11,500	0.15	29,000	48	121



Department for  
**Education**



centre for  
**science**  
education

**Copyright: 2011 Institute of Physics**

This resource is provided for your use, but the information, artwork and images are protected by copyright laws and may only be accessed and used for non-commercial, personal and educational purposes. No part of this resource may be permanently altered, copied or reproduced in any form, or reproduced in any way, including on any website, or stored in or transmitted to or from any hard-copy, electronic or digital form, in whole or in part, without the prior, written permission of the Institute of Physics.

Without further permission you can:

- > print pages for your personal or educational use
- > make multiple copies solely for educational use
- > where specified, download and manipulate content electronically for educational use

Any copyright notice originally included with the content must be included in all copies.

If you wish to request permission to use the content of the resources in any other way than those specified above, please contact the Institute of Physics [education@iop.org](mailto:education@iop.org).

Education department, Institute of Physics, 76 Portland Place, London, W1B 1NT 020 7470 4800

[education@iop.org](mailto:education@iop.org)

[www.iop.org/education](http://www.iop.org/education)