LIGHTS, CAMERA, ACTION

Have you ever seen a home video taken indoors on a gloomy day? If so, you'll appreciate just how important studio lighting is. Studio lighting has to be variable. Sometimes, a very bright light focused on a small area is needed. Other times the light needs to be dimmer or focused on a wider area. Television lighting engineers usually try to avoid lights that produce clear, black shadows. They use diffuse lighting or point several studio lights at the scene from different angles.

WHAT YOU HAVE TO DO

You are going to build a simple model of a studio light and investigate how it can be adjusted to 'flood' or 'zoom', and how the light intensity (brightness) varies. You may also be able to design your own investigation into other special effects.

EQUIPMENT

for the studio light

- 3 x krypton 3 V bulbs
- electrical tape
- connecting wire
- 30 cm ruler
- sticky tape
- 25 cm cardboard tube

for the investigations

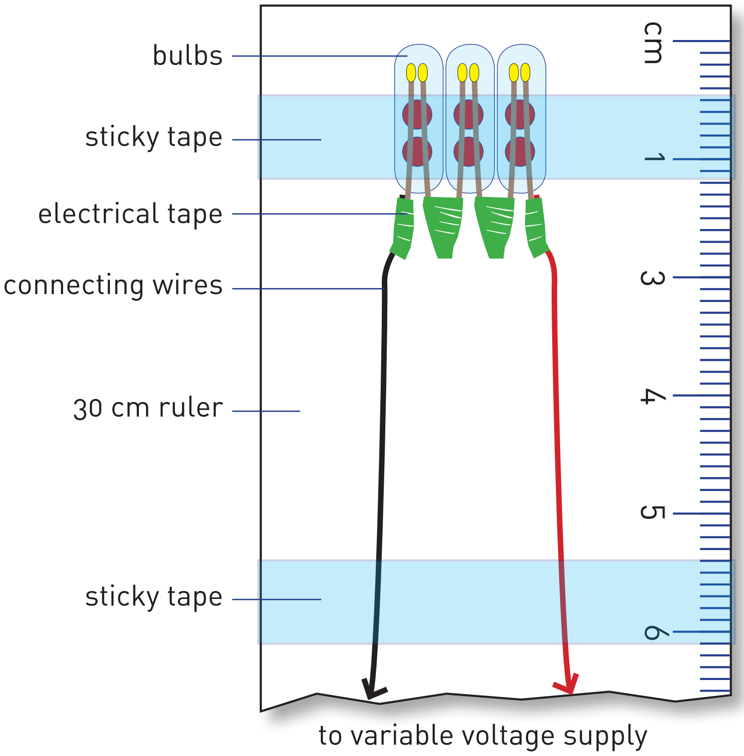
- variable voltage power supply (and access to mains electricity)
- plain white or graph paper screen, A3 size or larger
- clamps and stands to hold studio light and screen
- metre rule or tape measure
- large cardboard box or method of dimming laboratory lighting
- light dependent resistor (LDR)
- ohm meter measuring from 0 kilohms to 40 kilohms

SAFETY NOTES

Follow school safety rules when using electrical equipment. Take special care if the lighting in the laboratory is dimmed.

METHOD: MAKING A MODEL STUDIO LIGHT

1. Use electrical tape to connect the three bulbs in series. Make sure the 'leg' of each bulb is touching the 'leg' of the bulb next to it. See the diagram.
2. Use electrical tape to attach the connecting wires to each of the outside 'legs'. (Make sure the connecting wires are long enough to run the full length of the ruler with enough left to connect to a voltage supply.)
3. Use sticky tape to fasten the three bulbs onto the end of a 30 cm ruler. Make sure the tips of the bulbs are level with the 0 cm mark.
4. Tape the connecting wire along the length of the ruler, so it doesn't get tangled up.
5. Insert the 30 cm ruler, with the bulbs attached, into the cardboard tube so it can slide freely to and fro.
6. Your studio light is complete.



METHOD: FLOOD OR ZOOM

1. Make a studio light as above.
2. Connect it to a variable voltage power supply. Do not turn the voltage above 9 V.
3. Set up a screen for your studio light to shine at. How you do this depends on whether the lighting in your laboratory can be dimmed.

   If the lighting can be dimmed:

   - Arrange the cardboard tube horizontally, pointing at the white or graph paper screen, with the end of the tube 30 cm away from the screen.

   If the lighting in your laboratory cannot be dimmed:

   - Cut a hole in the centre of one side of your large cardboard box, just large enough to take the tube.
   - Cut a large hole in the opposite side of the box. Cover it with either the plain white paper or graph paper.
   - Place the box in as dim a part of the laboratory as possible, with the screen pointing away from windows or other sources of light.
4. Slide the ruler with the krypton bulbs down the tube until the circle of light almost fills the screen. Adjust its position until the bulbs are an exact number of centimetres from the front end of the tube.
   - You can calculate the distance of the bulbs from the front end of the tube by subtracting the reading on your ruler from the length of the tube.

     For example, if you used a 25 cm tube and the reading on your ruler (level with the back of the tube) is 20 cm, then the bulb will be:

     25 cm – 20 cm = 5 cm from the front of the tube.

5. Record the distance of the bulbs from the front of the tube. Record the width of the circle of light on the screen in the *first reading* column of your results table.
6. Move the bulbs so that they are 1 cm further from the front of the tube. Measure the width of the circle of light again. Record it in the table.
7. Repeat Step 5 until the bulbs are level with the back of the tube.
8. Repeat Steps 4 to 7 twice, so that you have three readings for the width of the circle for each distance of the bulbs.

RESULTS

distance of bulbs from front of tube / cm	width of circle of light on screen / cm			average width / cm
	first reading	second reading	third reading	

1. For each distance of light bulbs from the front of the tube, calculate the average (mean) width of the circle of light.
2. Use your results to plot a graph of *values of average circle width* (y-axis) against *bulb distance* (x-axis).
3. What does the graph tell you about the flood or zoom characteristics of your studio light?

EXPLANATIONS

1. Why is it important to take more than one reading for the width of the light circle for each bulb distance?
2. What are the advantages and disadvantages of using three krypton bulbs for the studio light, instead of one?
3. If you changed the distance between the front of the light (the cardboard tube) and the screen, what effect would this have on the circle of light, do you think?
4. Sketch two extra pencil lines on your graph to show the results you think you'd get if:
   - you increased the distance between the front of the studio light and the screen
   - you decreased the distance between the front of the studio light and the screen.

METHOD: LIGHT INTENSITY

You are going to use a light sensor to investigate exactly how the light intensity varies across the circle of light on the screen.

1. Connect a light dependent resistor (LDR) across a multimeter set to measure resistance. (Ask your teacher how to connect the LDR if you're not sure – it will depend on the type of LDR, multimeter and connectors that you have available.)
2. Position your studio light so that the front of the cardboard tube is about 30 cm from the screen.
3. Slide the bulb along the tube until there is a large circle of light on the screen, with just a few centimetres of dark screen visible each side of the circle.
4. Mark a scale horizontally across the screen.

   If you are using plain white paper:

   - Draw a horizontal line in pencil across the centre of the circle. Label a point a few centimetres to the left of the circle of light '0 cm'. Mark 1 cm intervals along the line until you reach the dark area on the right hand side of the circle.

   If you are using graph paper:

   - Choose the horizontal line that passes closest to the centre of the circle. Mark a scale on this line, using 1 cm intervals, starting with '0 cm' in the dark area to the left of the circle of light. Continue until you reach the dark area on the right hand side.
5. Place the LDR so that it is touching the '0 cm' mark. Measure its resistance using the ohm meter. Record the value in the *first reading* column of your results table.
6. Take measurements of the resistance of the LDR at either 1 cm or 2 cm intervals across your screen. Choose an interval appropriate for the size of your circle.
7. Repeat Steps 5 and 6 twice, so that you have three readings for the resistance at each position across the screen.

RESULTS

distance across screen / cm	resistance of LDR / kΩ			average resistance / kΩ
	first reading	second reading	third reading	

1. For each distance of your LDR across the screen, calculate the average (mean) value of the resistance of the LDR.
2. Use your results to plot a graph of average resistance against distance across the screen.
   - The average resistance of the LDR is the dependent variable, so it goes up the *y*-axis.
   - The distance across the screen is the independent variable, so it goes along the *x*-axis.
3. Draw a smooth curve through the points.

EXPLANATIONS

1. Describe how the resistance of the LDR changes as the light intensity changes.
2. Use your graph to describe how the light intensity of the studio light varies with the distance from the centre of the circle of light.
3. What are the effects of having three bulbs, instead of one, on the intensity of the light?

SOME MORE QUESTIONS

- Sometimes a lighting engineer may need to increase the area of the studio that is being lit, without decreasing the intensity of the light. It's possible to do this by using more than one studio light. Is it possible to change the studio light you built to achieve this? Discuss your ideas.
- Does the type of light bulb used for a studio light matter? Do some research to find out about different types of light bulbs and their main characteristics.

SOME MORE THINGS TO TRY

Real studio lights have *barn doors* on them – flaps that can be moved to change the way the light is directed. Investigate the effect that *barn doors* could have on your studio light. You might consider:

- the shape of the barn door
- where it is attached to the light
- what position it's in
- whether it's translucent or opaque.

Present a short report to another group, to explain what you find out.

HEALTH AND SAFETY

A risk assessment must be made before starting any practical work.

Make sure students follow school safety rules when using electrical equipment and take care if the lighting in the laboratory is dimmed.

THE INVESTIGATION

Studio lights are designed to be able to provide lighting that varies in both the area covered by the light and the intensity of the light. Special effects or multiple lights may be used to produce shadows or – more often - absence of shadows, to produce coloured light or to block light to specific areas.

Students build a very simple studio light that is, in essence, a torch in a tube. By varying the distance between the bulbs and the front of the tube they are able to investigate how the area being lit varies.

Students also use a very simple light meter, made from an LDR connected to an ohm meter, to investigate how the light intensity varies across a circle of light seen on a screen. An alternative would be to find out how the intensity of the light at a given position on the circle of light (for example the centre or the edge) varies with the size of the circle of light.

RESULTS

This investigation is undoubtedly easier to do if the lighting in the laboratory can be dimmed. It does not have to be dark, just dim enough that the circle of light (roughly equivalent to a bright torch) will show up clearly on a screen about 30 cm from the studio light. If it is not possible to dim the lighting, the studio light can be shone into a large cardboard box, with one side removed and replaced by paper to act as the screen.

If the distance between the front of the tube and the screen is set to approximately 30 cm it is relatively easy to adjust the maximum size of the circle of light so that it fits on a screen made from an A3 sheet of paper. The screen can be either blank paper, in which case students need to use a ruler to measure the diameter of the circle of light, or graph paper, in which case the size of the circle can be measured by counting the squares.

SUGGESTED SEQUENCE

Group sizes here will be determined by simple practical issues, such as access to equipment and to darkened areas or large boxes. Both activities could be carried out by students working in pairs. Groups larger than three may result in some students having nothing to do while readings are being taken and recorded. Evaluation and explanation work could be done either in the groups used for the practical activities themselves, in larger groups or as a whole class activity, sharing knowledge, ideas and expertise.

Time required

Each of the practical investigations will be completed by students in one practical session, though you may wish to allow further time for plotting graphs and evaluating results. The additional investigations can be either open-ended or more constrained; open-ended activities will require more time for students to plan the investigations they wish to carry out.

Notes

The light bulbs: The light bulbs suggested are 3 V krypton bulbs, needing a current of 300 mA, and having a lifetime of approximately 100 hours. These give a brighter light than LEDs, which makes it easier to carry out the investigation if the laboratory lighting cannot be significantly dimmed, but LEDs could be used instead. An ordinary torch bulb could also be used, but this has the disadvantage of being both dimmer than LED or krypton lights and of giving a less sharply-edged circle of light.

The cardboard tube: The cardboard tube needs to be 25 cm long. The cardboard tube from a roll of kitchen towel is an appropriate length to give a good range of results. 50 mm drainpipe tube would be a more robust alternative. Students will find it easier to measure the distance of the bulbs from the front of the tube if the tube is cut so that its length is an exact number of centimetres.

Using a reflector: Using the cardboard tube from a roll of kitchen towel has the disadvantage that it has a relatively narrow diameter, making it hard or impossible to fit a reflector behind the bulbs. Since the main effect of the reflector is to increase the amount of light given out at the front of a studio light, this is not critical to the operation of the studio light. Students could be asked to investigate the effect on the circle of light they observe when a reflector – either a plane or concave mirror – is placed over the back of the tube. Alternatively, a larger diameter tube could be used, allowing a concave mirror to be placed as a reflector behind the bulbs and moved as the bulbs move. In this case, the ideal distance between the bulbs and the mirror is the focal length of the mirror.

The light sensor: By far the simplest light sensor to use is a small LDR connected across an ohm meter. The recommended LDR (Maplin part number N46AY) is a small size, making it easy for students to measure the light intensity at positions that are relatively close together, for example every 1 cm across the width of the circle of light. This is specified as having a resistance in darkness from 9 kΩ to 20 kΩ, but the tolerance is very large and values from < 1 kΩ to > 35 kΩ are likely to be obtained, depending on the lighting level.

TECHNICIAN EQUIPMENT LIST

to make a studio light:

- 3 x krypton 3 V bulbs *(Maplin JX48)*
- electrical tape
- connecting wire
- 30 cm ruler
- sticky tape
- 25 cm cardboard tube

to carry out the investigations, each group will need:

- variable voltage power supply (and access to mains electricity)
- plain white or graph paper screen, A3 size or larger
- clamps and stands to hold studio light and screen
- metre rule or tape measure
- large cardboard box or method of dimming laboratory lighting
- light dependent resistor (LDR) *(Maplin N46AY)*
- ohm meter measuring from 0 kilohms to 40 kilohms

TECHNICIAN NOTES

- The suggested bulbs are 3 V krypton bulbs (Maplin part number JX48). These bulbs need a current of 300 mA. Check the current supplied by your power supply and insert resistors if necessary.
- Alternatively, LED lamps could be used, but the krypton bulbs give a brighter light.
- A 9 V battery could be used to power the bulbs instead of a variable voltage power supply.
- The cardboard tube from a roll of kitchen towel is suitable and easy to obtain. 50 mm drainpipe tube could be used as an alternative.
- If students are to cut holes in the cardboard boxes they will need scissors to do so.