theme: entertainment & culture

job:
Suresh Chawla, Theatre technician, Salisbury Playhouse

activity outline

In the video we see Suresh talk about moving scenery around the stage during a production. We see him on his balcony using the system of pulleys that lift and lower scenery on and off the stage.

In this activity pupils set up and investigate different systems of pulleys. They use some suggested ways of threading the pulleys and then try to design their own system.

You will need one lesson.

Setting up the pulley systems isn’t easy – pupils may need some help or, in some cases, you may wish to set up the equipment for them.

The pupil sheet provides an introduction, step-by-step instructions, and diagrams of the pulley systems.

Teacher notes overview

1 Curriculum links: where this activity can fit with the 2008 KS3 Programme of Study and Scottish 5-14 Science Curriculum.

2 The Video: providing a synopsis of the video content and ideas for viewing.

3 The Practical: including Equipment lists, Health and safety notes, a Possible approach (a comprehensive, suggested way of planning the lessons) and an Underlying science section (providing detailed information about the various scientific principles involved).

4 Possible extensions: suggestions for other practical activities using the video, or extending the suggested activity.

5 Associated jobs: guidance on how to deliver a plenary activity (or, if you wish, a stand-alone activity) focusing on the video interviewee, including a photo of the interviewee to place at the centre of a spider diagram.
This lesson can be used to help teach part of the 2008 Key Stage 3 Programme of Study (England and Wales):

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This lesson can be used to help teach part of the Scottish 5-14 Science Curriculum:

**Main curricular links**

- E&F3 Forces and their effects

**Attainment Targets**

**Knowledge & understanding:**

- **Level E**
  - describe the effects of balanced and unbalanced forces

- **Level F**
  - distinguish between mass and weight
  - name the newton as the unit of force and explain its relationship to mass

**Investigating skills:**

- **Level D**
  - make an appropriate series of accurate measurements
  - select an appropriate way to record findings
  - draw conclusions consistent with the results

- **Level E**
  - plan a valid and reliable test for given hypothesis
the video

Synopsis of the video

Among other things, Suresh makes these interesting points:

- Theatre technicians have to move heavy bits of scenery from one place to another.
- They work closely with set designers and set builders to establish which materials to use.
- There is an artistic element to his job – not only does he move scenery, but when it’s in view of the audience it must fit with the director’s style.

Watching the video

There are a number of things you might do before showing the video to your class.

1. Preview the video and write a few quick-fire questions. Then you can tell your class that they will be tested on their observation when it’s finished. This is an excellent way of encouraging them to pay attention!

2. Ask pupils to watch the video through once. Then ask them to generate one question that could be answered from the video and one question they would like it to ask but the video did not answer. These questions are then exchanged with another pupil and the video is watched a second time. This gives pupils an opportunity to focus on something they may have missed first time, and provides a basis for discussion on what was learnt from the video and what additional information is needed.

3. Ask pupils what sort of person might become a Theatre Technician. Does anyone in the class think they’d like to work in a theatre? When the video has been watched, ask the questions again. Has anyone changed their mind/opinions?

4. Ask pupils to spot the science in the clip.
the practical

Equipment

(per pupil/pair/group)

- clamp stand
- G-clamp
- 2 double pulley blocks (+ 2 single pulleys if required – See Possible approach below)
- 1 kg mass
- 10 N forcemeter (to match mass used)
- thread (about 1 m)

For ease of manipulation, and to speed up the practical, it is suggested that a quick method of attaching and detaching the thread should be arranged – such as S-hooks and a ready-made loop on the thread.

Health and safety

- To avoid tipping, clamp the clamp stand to the bench. (If G-clamps are unavailable, instruct pupils to hold the top of the stand when the thread is pulled or to use a smaller load, e.g. 100 g.)
- When lifting the mass, raise it only a few centimetres off the bench or floor.
- Keep fingers and toes away from beneath the suspended mass. Preferably place a bucket of waste paper, or similar, under the load, to keep toes out of the way.

Possible approach

The video shows how Suresh, a theatre technician, can move heavy scenery using a pulley system. Pupils investigate the use of pulleys on a small scale, but need to appreciate that the principles they discover apply equally to heavy loads.

Depending on the group, two concepts may be discussed before part A, or after, when they may have discovered it for themselves:

- the relationship between grams and newtons;
- the difference between the force needed to suspend the mass (balanced forces), and that needed to lift it (unbalanced forces).

Allow pupils to work through A to D.

[Note: If using double pulley blocks as singles in parts B and C is considered potentially confusing, just use single blocks – but these will need changing for parts D and E, taking up more time.]
Discuss their findings before they try part E. They should have found that:

\[ \text{force with } n \text{ pulleys} = \text{force with no pulley} \div n \]

Do not elaborate at this stage.

For part E, encourage pupils to devise their own method of threading the three pulleys. They could also be given another single pulley so they can use three separately. Encourage some to attach the mass to the string instead of a pulley block. Possible arrangements include:

Comparing results, they will find that some arrangements conform to the above formula, but not all. They should sketch at least one arrangement that does, and one that doesn’t.

For those who have not already spotted the relationship, direct attention to the number of threads on which the mass hangs. This equals the number of pulleys in worksheet Figures 1 to 3, but not in some of their 3-pulley arrangements.

They should now be able to conclude that:

\[ \text{force with } n \text{ supporting threads} = \text{force with 1 thread} \div n \]

Explain that this is because the tension force is now evenly divided between the supporting threads.

Note that the thread they pull down to lift the mass is not included, since the mass is not hanging on this section of the thread. (However, if this free end has to be pulled upwards, then it is included, since the mass is hanging on it.)

Ask what other factors are likely to affect the required force, leading to a discussion of friction. The effect may be significant in larger systems lifting heavy loads, but is unlikely to be measurable with the simple equipment in these experiments.

Brighter pupils may also spot that the movable pulleys are also lifted, which requires energy.

If appropriate, discuss Mechanical Advantage, \( \text{MA} = \frac{\text{load}}{\text{effort}} = \frac{\text{weight lifted}}{\text{force required}} \)

[Note: Convert mass (g) to weight (N)]

For the pulley systems above: \( \text{MA} = \text{number of supporting threads}. \)
Underlying science: Basic principles

- Force of gravity on 1 kg is about 10 N
- An upward force greater than 10 N is required to raise the mass, giving it upward velocity
- When the mass is suspended, the upward and downward forces are equal and opposite
- The thread transfers energy from human muscles to the load
- The force in the thread is called tension
- Some energy losses occur through friction

Underlying science: Role of pulleys

- A single pulley does not alter the force; it merely changes its direction
- This is helpful since it is easier for a person to pull downwards than upwards
  - and also safer than lifting a heavy weight with a bent spine
- Multiple pulleys, suitably threaded, reduce the force needed to lift or suspend the mass
  - so human energy can lift objects that would otherwise be too heavy
- The more pulleys, the smaller the force needed – though the reduction depends on how they are threaded
  - The load is distributed evenly between the threads that support it
  - In some arrangements a particular pulley may alter only the direction, not the force
- Some pulleys in a system (or block and tackle) are fixed; others move during lifting
- Depending on the system, the load may be attached to the thread or to a pulley block
possible extensions

1. Devise other methods of threading up a 4-pulley system. Check whether the **supporting threads** rule applies in each case.

2. Measure how far the thread end has to be pulled in order to raise the mass by, say, 10 cm. Compare this for different pulley systems. If appropriate, discuss Velocity Ratio, VR (= distance moved by the applied force ÷ distance moved by the load).

3. Brainstorm and discuss other work and leisure examples of the use of pulleys. These might include:
   - cranes
   - chain hoist, e.g. removing a car engine
   - rigging to raise sails on a **tall ship**.

associated jobs

A STEM (Science, Technology, Engineering and Maths) education provides pupils with skills and knowledge that are useful in all sorts of careers. The video demonstrates how Suresh, a Theatre Technician, uses such skills on a daily basis.

Suresh works with numerous people – some directly, some indirectly. Some use STEM skills, others don’t. By exploring this network of associated jobs, pupils will, hopefully, begin to see that even those in non-STEM jobs will find STEM skills useful – if they’re communicating with someone “in-STEM”, for example, some knowledge of their work will be a great help.

Suresh’s spider diagram

Try placing Suresh at the centre of a spider diagram (we’ve provided a photo of Suresh which you could use). You could either create worksheets for pupils to complete themselves, or create the diagram on your whiteboard and then pool ideas.

Ask pupils: “who does Suresh work with”. They may draw information from the video – the set designer or the carpenters in the workshop, for example – or they may come up with new ideas, such as actors, producers, costume designers or sound engineers. Other, less obvious, suggestions might include outside agencies who rig equipment to make humans *fly* (the theatre isn’t insured to do this themselves), or people working in maintenance, who check the safety and repair damage to the stage.

Now ask pupils which of those jobs are clearly “in-STEM”. Who else might find some STEM skills helpful? Why?

You could extend this by taking any one of the associated jobs and placing them at the centre of a spider diagram, and starting the process again.
Suresh Chawla, Theatre Technician, Salisbury Playhouse

Studying science and maths can transform your career options. Future Morph: become someone.