AMSP Professional development videos: Mechanics

Aims of the session
■ To encourage teachers to reflect on their own practice and explore ways of helping students to understand the action of forces. ■ To provide teachers with the opportunity to explore the value of practical experiments and devise ways to incorporate practical work into their lessons.
Resources needed
■ A projector for showing the videos. ■ Various practical equipment as detailed in the experiment guidance sheets.

Introduction

Watch the **using physical phenomena** video, which shows a teacher encouraging her students to engage with mechanics through a range of practical tasks. After watching the video you might like to discuss the following questions (be strict with yourself and allow separate time for each question!):

- What are the advantages of practical work in mechanics lessons?
- What are the disadvantages of practical work in mechanics lessons?
- How can potential disadvantages be overcome?

Hopefully teachers will identify some of the following as possible advantages:

- It helps students to visualise the effect of forces.
- It can remove common misconceptions about how forces work.
- It will help students to relate to abstract questions in a text book.
- It can help to build confidence and break down anxiety around the topic.
- It encourages students to work collaboratively and discuss their ideas.
- It is enjoyable and provides an opportunity for different teaching methods.

The following are likely to be included amongst the possible disadvantages. It is important to stay open-minded for this session, so possible responses to these concerns are suggested:

- It is too time-consuming – we are under pressure to complete the syllabus. Many experiments are quick and can be done as part of a lesson, rather than taking over a whole lesson. Often investing a little time in this sort of work early on can save time that might otherwise need to be spent at a later date working with confused or unconfident students.
- We do not have the necessary equipment. It is likely that much of what is needed can be borrowed from the school/college's science or physics department. Where this is not possible, many of these experiments require materials that are cheaper than people might first think.

- It can be hard getting access to labs/specialist rooms. These experiments are designed to be carried out in a normal classroom.
- Some students don't like practical work. Many do, and those that don't are still likely to benefit from the experience. Adapting to different teaching styles also helps students to become more effective learners in their future studies.

The follow up task allows time to try out some simple practical experiments which teachers might want to consider trying out in lessons.

Pair work

Select one of the practical tasks and begin by completing the experiment as if you were students in a mechanics lesson. The tasks used in the video could also be attempted. After completing the experiment once, discuss the following questions:

- What benefits might students gain from completing this experiment?
- At what point during the related topic would students most benefit from exploring this task?
- What are the logistical considerations of carrying out this experiment in a lesson?
- How accurate were the results that you obtained? Could any improvements be made?
- What modelling assumptions were made in the experiment?

If the group is large then share out the experiments and at the end of the session feedback by briefly describing the experiment you were allocated and giving your thoughts on the follow up questions.

If time allows discuss ideas for other possible experiments, or other areas of the mechanics syllabus where students' understanding might benefit from working on a simple practical experiment (see the link in 'Next steps' for ideas). You may want to produce a 'shopping list' of resources for the department to borrow or purchase for future lessons. A few fixable pulleys and a set of small adjustable weights would provide the basis for numerous experiments.

Next steps

The third video in the mechanics section shows the teacher discussing the benefits of the practical work with a focus group of students. Might this be something to consider if practical work is not a standard approach in your department?

The other videos in this section provide further ideas for how to develop approaches to teaching mechanics.

The Mechanics in Action guide can be downloaded from the STEM Learning website and has dozens of great ideas for practical experiments.

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Practical task A: Falling cone

Topic(s)

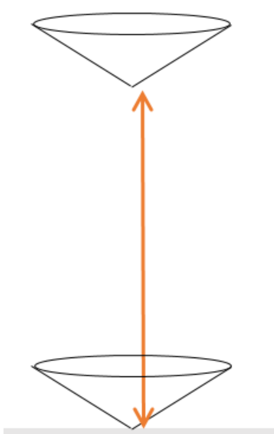
Newton's Second Law and two dimensional kinematics.

Equipment Needed

- Cone made from card or heavy paper.
- Tape measure.
- Stop watch.
- Scales to find the mass of the cone.
- A marble or similar small object.

The Experiment

Hold the cone at a good height above ground level – the greater the height, the lesser the effect of any error in the time measurement. Measure the distance that the cone will fall when released.



1. Record the time that it takes for the cone to fall from rest to ground level.
2. Use the equation $s = ut + ½at^2$ with $u = 0$ to find the acceleration. Note that this assumes the acceleration to be constant.
3. Use the equation $F = ma$ to find the resultant force acting on the cone.
4. By assuming that the only forces acting on the cone are its weight and a resistance force, find the magnitude of this resistance force.
5. Vary the mass of the cone by placing a marble or other small weight inside. Assuming that the resistance force remains the same, find the new resultant force on the cone and use this to predict the time it will take the cone to fall. Test to see if you were correct.

Questions to discuss

How significant was the assumption that the resistance force was constant? If it is not constant, how would the results change?

What is the likely degree of error in the time measurement? What steps could be taken to mitigate this?

What would happen if the cone had a different radius?

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Practical task B: Balancing ruler

Topic(s)

Moments.

Equipment Needed

- A metre ruler.
- Scales to find the mass of the ruler.
- A selection of weights of small objects of variable mass.
- Blu-tack or similar to attach the weights to the ruler.

The Experiment

Set up a satisfactory means of balancing the ruler, either on a finger or on some sort of pivot. Check that it balances when supported at its centre:

1. Attach a known/pre-weighed mass (100g or similar) to one end of the ruler. Balance the ruler and record the position of its balance point.
2. Use the theory of moments to estimate the mass of the ruler: For the diagram above, if the added mass is m, the mass of the ruler is M, and d is the distance from the end of the ruler to the pivot in centimetres, then $dm = (50 - d)M$.
3. Measure the mass of your ruler to check your accuracy.
4. Based on your results, estimate the position of the balance point if the attached mass is doubled/trebled. Check your theory.
5. Try experimenting with multiple masses in different positions.

Questions to discuss

Is the mass of the Blu-tack significant?

How accurate are the measurements? Is it feasible for the distances to be correct to the nearest mm? What about the accuracy of the mass measurements?
How significant is the width of the pivot?

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Practical task C: Exploring forces

Topic(s)

Force diagrams and Newton's Third Law.

Equipment Needed

- Bathroom scales (Two if possible).
- A large pole (a sturdy metre ruler or broom would be suitable).
- Access to a lift, if possible.

The Experiment

Rather than attempting to obtain numerical data, the purpose of this experiment is to experience and understand the different forces we experience, and to represent these in diagrams.

1. Stand on the scales. What forces are acting on you? Draw a force diagram. What forces are acting on the scales? Draw a force diagram.

2. Whilst standing on the scales, press down on the floor with your pole. What happens to the reading on the scale? Why? Can you explain using a diagram?

3. Try the following things whilst standing on the scales. Try to explain what happens as above:
   Press down on the *scales* with the pole.
   Use the pole to push up on the ceiling.
   Raise one leg off the scales.
   Place one leg on the scales and one on the floor.
   Place each leg on different scales. Lean from side to side.
   If one is available, repeat these experiments in a lift moving upwards and downwards.

Points to discuss

The important thing to appreciate is that the scales measure reaction force, which can be varied, rather than the occupant's weight/mass.

What is significance of Newton's Third Law to these experiments?

If we had a sturdy plank in addition to two scales what experiments could be carried out to explore the concept of moments?