O3 • Solving problems using Newton's second law

Mathematical goals

To help learners to:

- understand how Newton's second law can be applied to a range of different problems.

To encourage learners to:

- link the stages of solutions together;
- appreciate the purpose and relevance of each stage of a solution.

Starting points

Learners should have some knowledge of Newton's second law and how to resolve vectors.

Materials required

For each learner you will need:

- mini-whiteboard

For each small group of learners you will need:

- Sheet 1 – *Problem 1*;
- Sheet 2 – *Problem 2*;
- Sheet 3 – *Problem 3*;
- Sheet 4 – *Problem 4*;
- Sheet 5 – *Problem 5*.

Time needed

At least 1 hour.

Suggested approach

Beginning the session

Explain that learners will be given one part of each of five different problems. The task is to complete each problem by providing the missing parts.

Working in pairs

Ask learners to work in pairs. Give each pair a set of five problems (Sheets 1–5). Ask learners to suggest ways of completing the other four parts of each problem so that they fit with the one part that is given.

Whole group discussion

When learners have finished at least three of the problems, whole group discussion can revolve around the suggestions they have written and whether they are appropriate. For example, pairs can take it in turns to read out their suggested version of Problem 4. After each version, the rest of the learners can draw the force diagram appropriate to that problem and check it against the original suggestion from the learners. Mini-whiteboards could be used for this.

Some learners can read out their suggestions for Problems 2 and 3. After each suggestion is read out, discussion can revolve around whether it is appropriate for the diagram in Problem 2 or the resolved forces in Problem 3. Final solutions for these problems can also be checked against each other.

The assumptions can also be discussed and added to if appropriate.

Groups can exchange sheets to check whether the diagrams, components and solving fit together. Any discrepancies can be resolved through whole group discussion.

Reviewing and extending the learning

Ask pairs of learners to go back to Problem 1 in the light of the whole group discussions and make any adjustments that they feel are necessary. Exchange the solutions to Problem 1 between pairs and ask them to check that all parts are correct.

Solutions can be extended to more generalised situations.

What learners might do next

Link in with the laws of motion for constant acceleration by using the acceleration from Newton's 2nd law to determine speeds and/or distance and time.

Further ideas

This approach can be used whenever a solution has several stages that are linked together. It is particularly suitable for any mechanics problems that require several stages, e.g. a problem, a diagram, a solution and assumptions.

Not all the problems have to be given out together. Some could be held back to give out after discussion, or just a selection could be used for the session.

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O3 Sheet 1 – *Problem 1*

Problem

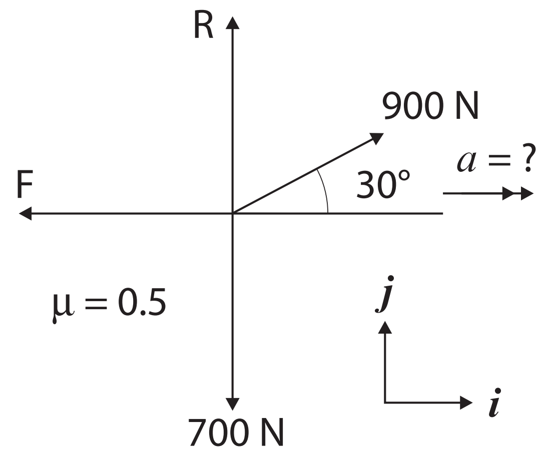
Peter and Andrew have been persuaded by Timothy to push him on his sledge. Timothy and his sledge have a combined mass of 50 kg. Timothy wants to go really fast but Peter and Andrew are feeling tired after lots of snowballing and making a big snowman. They reckon that they can only manage a horizontal push of 300 N between them. Timothy wants to know how much acceleration this will give him. If the coefficient of friction between the sledge and the ground is 0.4, what is the acceleration of the sledge?

Force diagram:	**Resolving into components:**
Solving:	
Assumptions:	

O3 Sheet 2 – *Problem 2*

Problem

Force diagram:



Resolving into components:

Solving:

Assumptions:

O3 Sheet 3 – *Problem 3*

Problem

Force diagram:

Resolving into components:

$\boldsymbol{i}$: $100 \cos 40° + P \cos 60° - 25 = 80a$

$\boldsymbol{j}$: $100 \sin 40° - P \sin 60° = 0$

Solving:

Assumptions:

O3 Sheet 4 – *Problem 4*

Problem

Force diagram:	**Resolving into components:**

Solving:

$R = 600 - 500 \sin 50° = 217.0$ N
$F = 500 \cos 50° - 180 = 141.4$ N
$F = \mu R \Rightarrow \mu = F \div R = 141.4 \div 217.0 = 0.65$

Assumptions:

O3 Sheet 5 – *Problem 5*

Problem

Force diagram:	**Resolving into components:**
Solving:	
Assumptions: The acceleration of the lift remains constant at 5 m s^{-2}. The man remains still and in contact with the floor of the lift.	