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WORKSHEETS
ATTEMPT | CHECK | CORRECT | IMPROVE

Forces on slopes worksheet

AQA AS 7407 and first-year A Level 7408 | OCR A AS H156 and A Level H556

35–40 minutes independent practice + 15–20 minutes review | 31 marks

Specification points covered

AQA 7407 / 7408: 3.4.1.1 selected vector resolution, inclined-plane forces and equilibrium; 3.4.1.5 selected constant-mass second-law applications.
OCR A H156 / H556: 2.3.1(d); 3.2.1(a), (c), (d) tension, normal force and friction only, (e), (f) resolved straight-line motion. Upthrust is not assessed here.

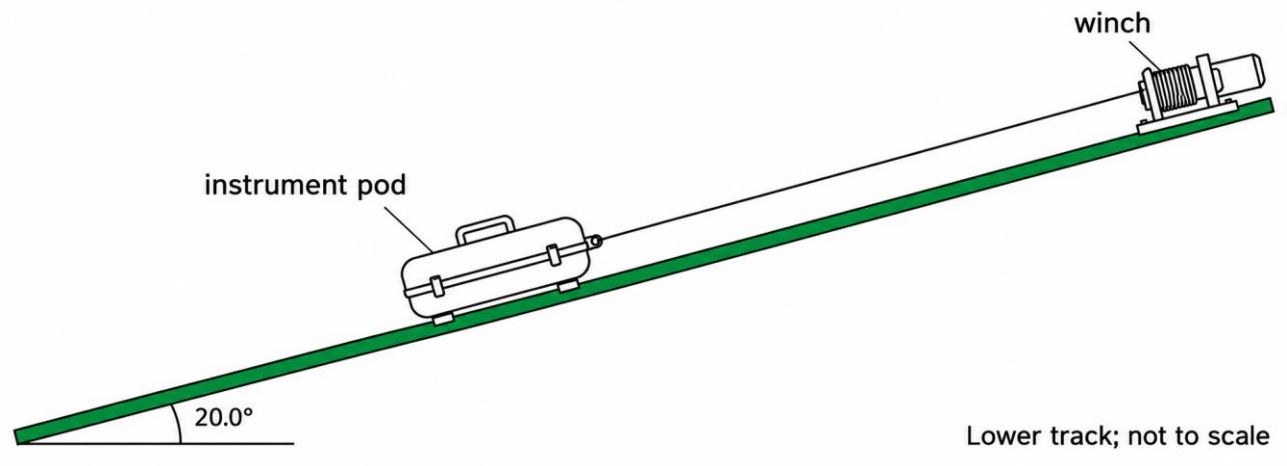
Main scenario

A field team winches a 30.0 kg instrument pod up the access track to a cliffside weather station. The lower track is at 20.0° to the horizontal. The cable is always parallel to the local track.
Take uphill as positive and g = 9.81 m s^{-2}. Neglect air resistance. Friction is negligible unless a force is supplied. Keep guard digits when using earlier results.

Force and motion language

Identify the forces on the pod, then resolve along and perpendicular to the track. A force is measured in N; acceleration is measured in m s^{-2}.

A The lower-track model



1. Calculate the weight of the instrument pod. [1 mark]

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A Forces and motion on the lower track

2. In the blank space below, draw a free-body diagram for the pod. Include and label all the forces acting on it. Friction is negligible. [3 marks]

3. Calculate the component of the pod's weight parallel to the 20.0° track. State its direction. [1 mark]

4. Calculate the normal contact force exerted by the track on the pod. [1 mark]

5. The tension in the cable is 165 N. Calculate the acceleration of the pod. Friction is negligible. [2 marks]

6. A pupil writes, 'the tension causes a 165 N acceleration'. Explain why this is not a correct description. Use the terms tension, resultant force and acceleration. [2 marks]

7. The cable tension is adjusted so that it equals the component of weight parallel to the track. The pod is moving uphill. Describe its subsequent motion and explain your answer. [2 marks]

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B Friction and the winch setting

New condition
During the next haul, a frictional force of 18.0 N acts down the track while the pod moves uphill.

8. The pod now experiences a frictional force of 18.0 N down the track. Calculate the cable tension required for it to move uphill at constant velocity. [2 marks]

9. The cable tension is increased to 160 N while the frictional force remains 18.0 N. Calculate the acceleration of the pod. [2 marks]

10. State the direction of the frictional force on the pod while it moves uphill. Explain why friction acts in this direction. [2 marks]

11. The track becomes wet and the frictional force decreases to 8.0 N while the tension stays at 160 N. Calculate the new acceleration. State how it compares with your answer to question 9. [2 marks]

C The steeper upper track

New condition
The pod reaches a straight upper section of track at 30.0° to the horizontal. For questions 12-17, the pod still has a mass of 30.0 kg unless stated otherwise.

12. Calculate the component of the pod's weight parallel to the 30.0° track. State its direction. [1 mark]

13. Calculate the normal contact force exerted by the 30.0° track on the pod. [1 mark]

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C Upper-track operating decisions

Continue on the 30.0° track. Use 30.0 kg except for the sleeved pod in Q16; Q17 explicitly returns to the original pod.

14. The frictional force is 20.0 N and the cable tension is 200 N. Calculate the acceleration of the pod on the 30.0° track. [2 marks]

15. The winch has a safe maximum cable tension of 220 N. Determine whether it can accelerate the pod at 1.50 m s^{-2} on the 30.0° track against a frictional force of 20.0 N. Show your reasoning. [3 marks]

16. A protective sleeve increases the mass of the pod to 38.0 kg. The cable tension is 220 N and friction is 20.0 N. Calculate the acceleration on the 30.0° track. [2 marks]

17. For the original 30.0 kg pod without the protective sleeve, a pupil says, “At 30.0°, the normal contact force is 30% of the weight because the slope is 30.0°.” Explain why this is incorrect. State the correct relationship and use it to calculate the normal contact force. [2 marks]

Review: resolve the actual force directions, use the resultant in F = ma, and state the physical assumptions behind the normal-force calculation.

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