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WORKSHEETS
ATTEMPT | CHECK | CORRECT | IMPROVE

OCR A A Level Forces on Slopes worksheet

35-40 minutes independent practice + 15-20 minutes review

Specification points covered

- 3.2.1(a) Apply Newton's second law, F = ma.
- 3.2.1(c) Understand weight of an object, W = mg.
- 3.2.1(d) Define and identify tension, normal contact force, upthrust and friction.
- 3.2.1(e) Draw and interpret free-body diagrams.

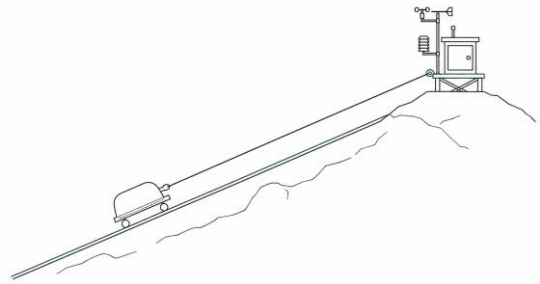
Main scenario

A field team uses a battery-powered winch to haul a 30.0 kg instrument pod up the access track to a cliffside weather station. The cable is parallel to the track. Take g = 9.81 m s^{-2} throughout.

Use throughout

Choose a positive direction along the track. For a pod on a slope: component of weight parallel to track = W sin θ; normal contact force = W cos θ.
A force can cause an acceleration. Use force in N and acceleration in m s^{-2} precisely.

1. Lower track: forces and resultant force



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

1. Lower track: forces and resultant force continued

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. [2 marks]

4. Calculate the normal contact force exerted by the track on the pod. [2 marks]

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

1. Lower track: forces and resultant force continued

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]

2. Lower track: friction

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]

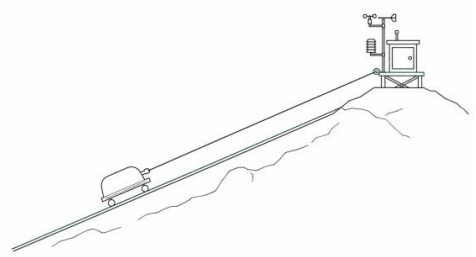
10. State the direction of the frictional force on the pod while it moves uphill. Explain why friction acts in this direction. [2 marks]

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]

3. 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. [2 marks]

13. Calculate the normal contact force exerted by the 30.0° track on the pod. [2 marks]

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]

3. Steeper upper track continued

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. 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 give the normal contact force for this pod. [3 marks]

Review and improve

- □ I can draw a free-body diagram with forces in the correct directions.
- □ I can resolve weight into components parallel and perpendicular to a slope.
- □ I can use the resultant force, not an individual force, in F = ma.