Work against Resistance: the Energy Audit

Specification: AQA 7367: MC1, MC2, MC3 · Edexcel 9FM0: FM1 Work, energy and power

INDEPENDENT

You do

A · Work against resistance

R = mg cos θ on a slope; F = μR; work = Fd.

1 A box of mass 6 kg slides 3 m down a rough plane inclined at 20° to the horizontal. The coefficient of friction is 0.3. Take $g = 9.8$ m s^{-2}.
(a) Find the normal reaction.
(b) Find the friction force.
(c) Find the work done against friction.

2 A car of mass 1200 kg brakes on a level road. Its speed falls from 25 m s^{-1} to 10 m s^{-1} while it travels 80 m. Find the constant braking force.

3 A particle of mass 2 kg slides from rest 4 m down a rough slope inclined at 30° to the horizontal. A constant friction force of 6 N acts on it. Take $g = 9.8$ m s^{-2}. Find its speed after 4 m.

4 A ball of mass 0.4 kg is thrown vertically upwards at 15 m s^{-1}. Because of air resistance it rises only 9 m. Take $g = 9.8$ m s^{-2}. Find the work done against air resistance.

B · Rough slopes

Energy at start − work against friction = energy at end.

5 A particle of mass 3 kg is released from rest on a rough plane inclined at 25° to the horizontal. The coefficient of friction is 0.2. Take $g = 9.8$ m s^{-2}. Find its speed after it has slid 8 m.

6 A particle is projected at 9 m s^{-1} up a line of greatest slope of a rough plane inclined at 18° to the horizontal. The coefficient of friction is 0.3. Take $g = 9.8$ m s^{-2}. Find the distance it travels before it stops.

7 A crate of mass 5 kg is released from rest on a rough plane inclined at 35° to the horizontal. After sliding 6 m its speed is 7 m s^{-1}. Take $g = 9.8$ m s^{-2}. Find the coefficient of friction.

8 A box of mass 10 kg starts from rest and is pulled 5 m up a rough plane inclined at 15° to the horizontal by a force of 80 N parallel to the plane. The coefficient of friction is 0.25. Take $g = 9.8$ m s^{-2}. Find the speed of the box after 5 m.

C · Reasoning (no calculator)

Explain in words as well as numbers.

9 A puck is projected up a rough slope. It stops, then slides back. Explain why it returns to its starting point more slowly than it left.

10 A block is placed at rest on a rough plane inclined at θ to the horizontal. The coefficient of friction is μ. Use the energy for each metre down the plane to explain why the block slides only if $\mu < \tan\theta$.

11 A sledge slides 10 m down a slope. It loses 800 J of GPE and gains 300 J of KE.
(a) Find the work done against friction.
(b) Find the friction force, assumed constant.

D · Show-that, curved paths and time Use energy for speeds and distances; use Newton for time.

12 A particle is projected with speed u up a line of greatest slope of a rough plane inclined at θ to the horizontal. The coefficient of friction is μ.
(a) Show that it travels a distance $d = u^2/(2g(\sin\theta + \mu\cos\theta))$ before it stops.
(b) Find d when $u = 10$, $\sin\theta = 0.6$ and $\mu = 0.5$. Take $g = 9.8$ m s^{-2}.

13 A particle of mass 0.5 kg moves on a rough curved track. It passes A at 4 m s^{-1}. Point B is 2 m below A. The work done against resistance from A to B is 3.2 J. Take $g = 9.8$ m s^{-2}. Find its speed at B.

14 A particle is released from rest on a rough plane inclined at $30°$ to the horizontal. The coefficient of friction is 0.25. Take $g = 9.8$ m s^{-2}.
(a) Use energy to find its speed after it has slid 6 m.
(b) Use Newton's second law to find its acceleration, and hence the time taken.

15 A particle is projected at 6 m s^{-1} up a line of greatest slope of a rough plane inclined at $25°$ to the horizontal. The coefficient of friction is 0.2. Take $g = 9.8$ m s^{-2}.
(a) Find the distance it travels before it stops.
(b) It slides back. Find its speed when it returns to its starting point.

E · Exam-style question Show your method: marks are for working.

16 A sledge of mass 20 kg is released from rest at the top of a slope 30 m long, inclined at $15°$ to the horizontal. The coefficient of friction between the sledge and the slope is 0.1. At the bottom it moves, with no change in speed, on to rough horizontal ground with the same coefficient of friction. Take $g = 9.8$ m s^{-2}.
(a) Show that the work done against friction on the slope is 568 J, to 3 significant figures. [3]
(b) Use the work–energy principle to find the speed of the sledge at the bottom of the slope. [3]
(c) Find how far the sledge travels on the horizontal ground before it stops. [2]