Kinetic energy and the work-energy principle

Starter

1. Find the work done by a man in these situations:
   (a) He pushes a packing case of mass of 35 kg a horizontal distance of 5 m against a resistive force of 200 N. The mass starts and finishes at rest.
   (b) He is handed a packing case of mass 35 kg. He holds it stationary, at the same height for 20 seconds and then someone else takes it from him.

Working: (a) WD $= Fs = 200 \times 5 = 1000$ J

N.B. Since the packing case does not change height there is no work done against gravity so the mass of the case does not come into the calculation.

(b) 0 J

N.B. Since the packing case does not move there is no work done.

E.g.1. Find the kinetic energy of a rugby player of mass 90 kg running at 6 m/s.

Working: Kinetic energy $= \frac{1}{2}mv^2 = \frac{1}{2} \times 90 \times 6^2 = 1620$ J

E.g. 2 A car and driver have a total mass of 1000 kg. The car gains speed from 7 m/s to 13 m/s with constant acceleration over a horizontal distance of 200 m. Calculate the driving force.

Working: Change in KE $= \frac{1}{2} \times 1000 \times \left(13^2 - 7^2\right) = 60000$

Using WD $= Fs$: $60000 = F \times 200$ so $F = 300$ N

E.g. 3 A car is initially travelling at 6 m/s and then accelerates at a constant to 11 m/s over 350 m. Given that the resistance forces for 500 N. Given that the mass of the car is 900 kg, find the driving force of the engine.

Working: Let D be the driving force of the engine.

WD by driving force $= 350D$

WD against resistance $= 500 \times 350$

Change in KE $= \frac{1}{2} \times 900 \times (11^2 - 6^2)$

WD by driving force — WD against resistance = Change in KE

$$350D - 500 \times 350 = \frac{1}{2} \times 900 \times (11^2 - 6^2)$$

$$D \approx 609.3$$

The driving force of the engine is 609 N (3 s.f.)

E.g. 4 A ball of mass 1.2 kg moving with initial speed 20 m/s comes to rest after travelling 30 metres across a horizontal surface. Find the work done against resisting forces, and hence calculate the mean resisting force.

Working: WD against resisting forces $= \frac{1}{2} \times 1.2 \times 20^2 = 240$ J;

Using WD $= Fs$: $\quad 240 = F \times 30 \quad \Rightarrow \quad F = 8$

The mean resisting force is 8 N.

Video: Kinetic energy

Video: Work-energy principle

Solutions to Starter and E.g.s

Exercise

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