Power

Starter

1. A bicycle of mass 30 kg is pushed up a hill inclined at 15° to the horizontal. Calculate the work done, to the nearest J, in moving the bicycle 70 m, starting and finishing at rest.

Working: ***Either…***

WD = Gain in GPE: $WD = 30g \times 70 \sin 15 = 5326$ J

…or…

The force i.e. the weight, acts at an angle of 75° to the opposite direction of motion.

WD =Force × distance: $WD = 30g \cos 75 \times 70 = 5326$ J

The work done is 5326 J

E.g. 1 A hotel lift, of total mass 1200 kg, rises a distance of 60 m in 20 s. What is the power output of the motor?

Working: Power= $= \dfrac{WD}{t} = \dfrac{1200g \times 60}{20} = 3600g = 35280$ W

E.g. 2 A 160 kg barrel of bricks is raised vertically by a 2 kW engine. Calculate the distance the barrel will move in 7 seconds travelling at a constant speed.

Working: $P = Fv$: $2000 = 160g \times v \quad \Rightarrow \quad v \approx 1.2755$ m/s

Distance, $s = 7 \times 1.2755... \approx 8.93$ m

The distance the barrel will move in 7 seconds is 8.93 m (3 s.f.).

E.g. 3 A swimmer of mass 50 kg pushes off from the side with speed 0.8 m/s. She can develop power of 200 W, and the resistance of the water is 220 N.

(a) At what rate will she accelerate from the side of the pool?

(b) Assuming resistance is constant, what is her greatest possible speed?

Working: (a) Using $P = Fv$: $F = \dfrac{200}{0.8} = 250$ N,

Using $F = ma$: $250 - 220 = 50a \quad \Rightarrow \quad a = \dfrac{3}{5}$

She accelerate at a rate of 0.6 m/s^2.

(b) The maximum speed is when $a = 0$, so $F = 220$ N,

Using $P = Fv$: $200 = 220v \quad \Rightarrow \quad v = \dfrac{10}{11}$

Her greatest possible speed is $\dfrac{10}{11} \approx 0.909$ m/s.

E.g. 4 A winch operating at 1 kW pulls a box of weight 980 N up a smooth slope at a constant speed of 2 m/s. Calculate the angle the slope makes with the horizontal.

Working: Using $P = Fv$: $\quad 1000 = F \times 2 \quad \Rightarrow \quad F = 500$ N
Constant speed $\Rightarrow \; a = 0 \; \Rightarrow$ tension in rope = weight of box
$R(//)$: $\quad 980 \sin\theta = 500 \quad \Rightarrow \quad \theta \approx 30.7^\circ$
The angle the slope makes with the horizontal is 30.7° (3 s.f.)

Video: Power (constant speed then uphill)
Video: Power (accelerating then uphill)

Power EQ

Solutions to Starter and E.g.s

Exercise
p20 1E Qu 1-12

Summary
Power is measured in watts where 1 W $= 1$ J/s
Average power $= \dfrac{\text{work done}}{\text{time taken}} = \dfrac{WD}{t}$
Average power $=$ force $\times$ speed i.e $\quad P = Fv$