Work, energy and power

1 Work

Work(J) = Force(N) × Distance(m)
For work done against gravity, use vertical distance.

1.1 Work done against friction

Work done against friction is:

$$WD = \mu R \times \text{Distance}$$

Where the distance is in the direction of motion

2 Energy

$\mathbf{E_K = \frac{1}{2}mv^2}$

$\mathbf{GPE = E_P = mgh}$

3 Conservation of energy

A particle's total energy is constant if it is subject only to gravity (i.e. smooth surfaces)
If there are frictional forces to consider then the loss of energy is the work done by friction.

4 Power

Power = Force × Velocity
Usually given in kW

Work, Energy and Power Example - Conservation of energy

A block of mass 10 kg is pulled along a straight horizontal road by a constant horizontal force of magnitude 70 N in the direction of the road. The block moves in a straight line passing through two points A and B on the road, where AB = 50 m. The block is modelled as a particle and the road is modelled as a rough plane. The coefficient of friction between the block and the road is $\frac{4}{7}$

Calculate the work done against friction in moving the block from A to B.

Calculate the force of friction

$$F = \mu R = \frac{4}{7} \times 10g = 56N$$

Multiply force by distance to find work done

$$50 \times 56 = 2800J$$

The block passes through A with a speed of $2ms^{-1}$.
Find the speed of the block at B.

Subtract the work done against friction from the work done by the pulling force

$$70 \times 50 - 2800 = 700J$$

Write an expression for the change in kinetic energy

$$\frac{1}{2} \times 10 \times v^2 - \frac{1}{2} \times 10 \times 2^2$$

Set the excess energy from the work done equal to the change in kinetic energy and simplify

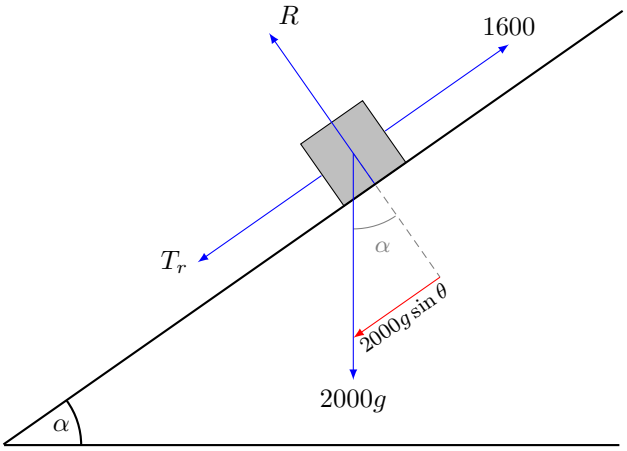
$$700 = 5v^2 - 20$$

$$v = 12$$

Work, Energy and Power Example - Power

A lorry of mass 2000 kg is moving down a straight road inclined at angle α to the horizontal,where $\sin\alpha = \frac{1}{25}$. The resistance to motion is modelled as a constant force of magnitude 1600 N. The lorry is moving at a constant speed of $14ms^{-1}$.
Find, in kW, the rate at which the lorry's engine is working.

Draw a diagram to represent the information



Equate forces

$$T_r + 2000g\sin\alpha = 1600$$

Solve

$$T_r = 1600 - 2000g \times \frac{1}{25} = 816N$$

Find power by multiplying force and velocity

$$P = Fv = 816 \times 14 = 11.4kW$$