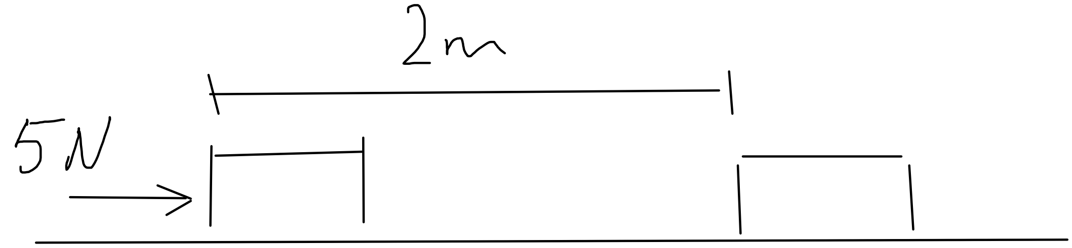
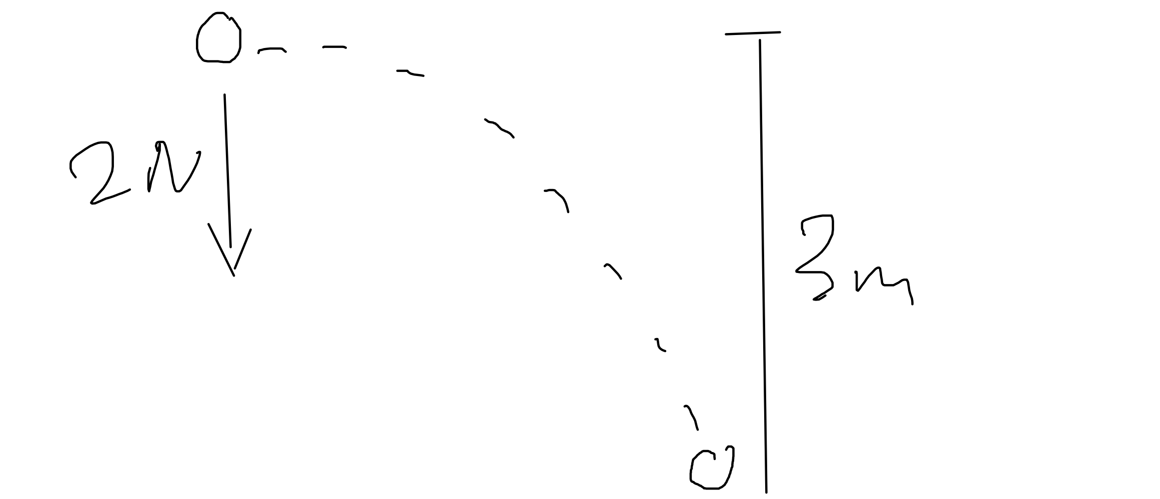
show an understanding of the concept of work in terms of the product of a force and displacement in the direction of the force

Work

Dr K M Hock



Work done = 5N x 2m = 10 J



Work done = 2N x 3m = 6J

Work done =

force x displacement

- in the direction of the force.

IMPORTANT! →

calculate the work done in a number of situations including the work done by a gas which is expanding against a constant external pressure: W = p ΔV

Expanding Gas

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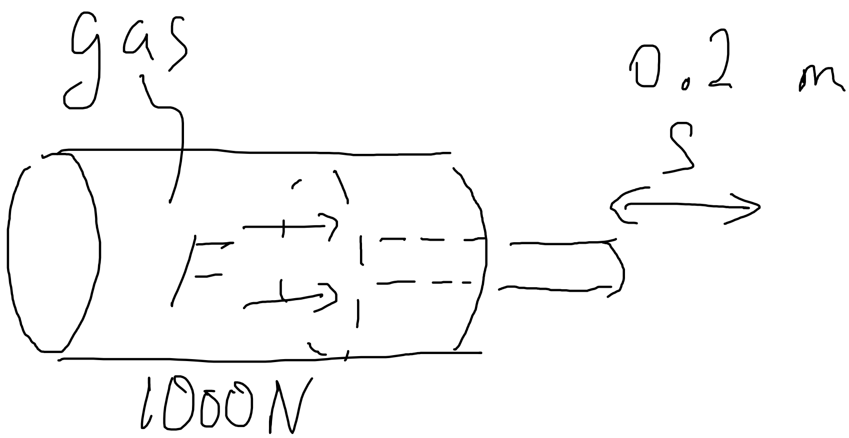
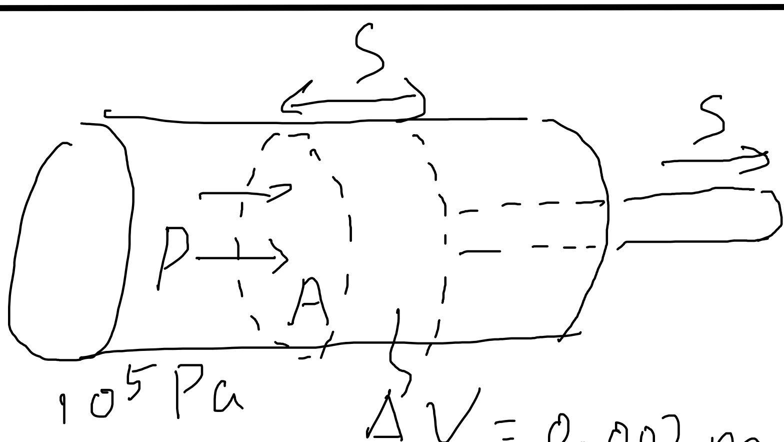


Work done = 1000N × 0.2 m = 200 J

= F × s



$$\text{Work done} = F \times s = p\overbrace{A \times s}^{\Delta V}$$

$$p\Delta V = 10^5\,\text{Pa} \times 0.002\,\text{m} = 200\,\text{J}$$

derive, from the equations of motion, the formula E_k = ½mv^2

Kinetic Energy

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work done → kinetic energy

$$Fs = \frac{1}{2}mv^2$$

Why?

Recall $v^2 = u^2 + 2as$ ($u = 0$)

$$v^2 = 2\left(\frac{F}{m}\right)s \quad \because F = ma$$

$$\therefore \frac{1}{2}mv^2 = Fs$$

Derived

Kinetic Energy 2

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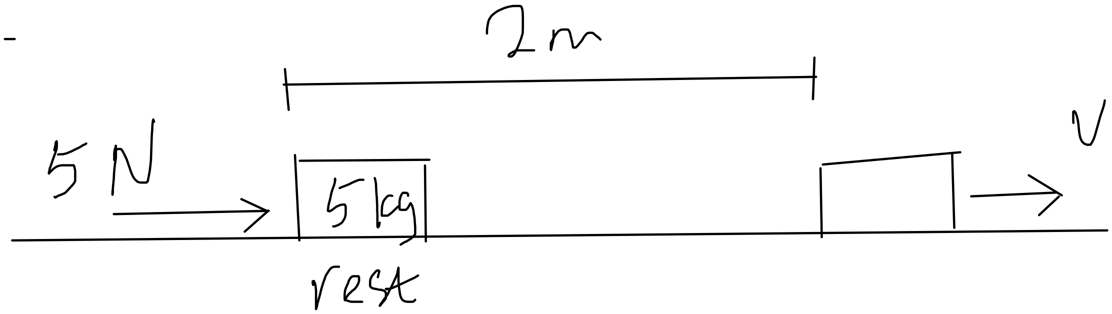
e.g.



Find the kinetic energy and final velocity.

KE = work done = 5×2 = 10 J.

$\frac{1}{2}mv^2 = 10$

$v = \sqrt{\frac{20}{m}} = \sqrt{\frac{20}{5}} = 2$ m/s

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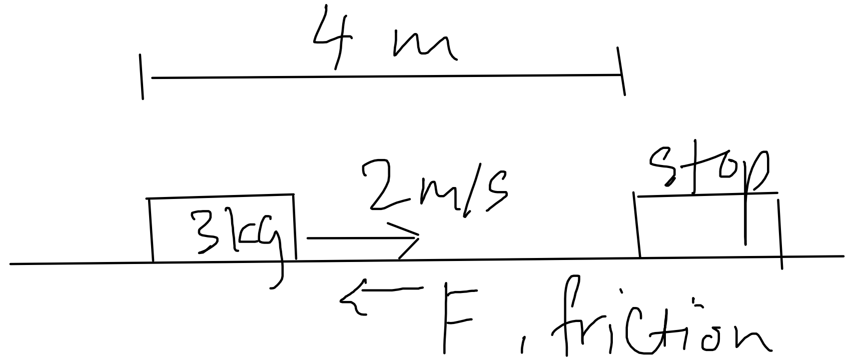
e.g.



Find intitial KE. Then find friction.

$KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 3 \times 2^2 = 6$ J.

$Fs = KE$

$F = KE/s = 6/4 = 1.5$ N.

show an understanding of and use the relationship between force and potential energy in a uniform field to solve problems

Uniform field

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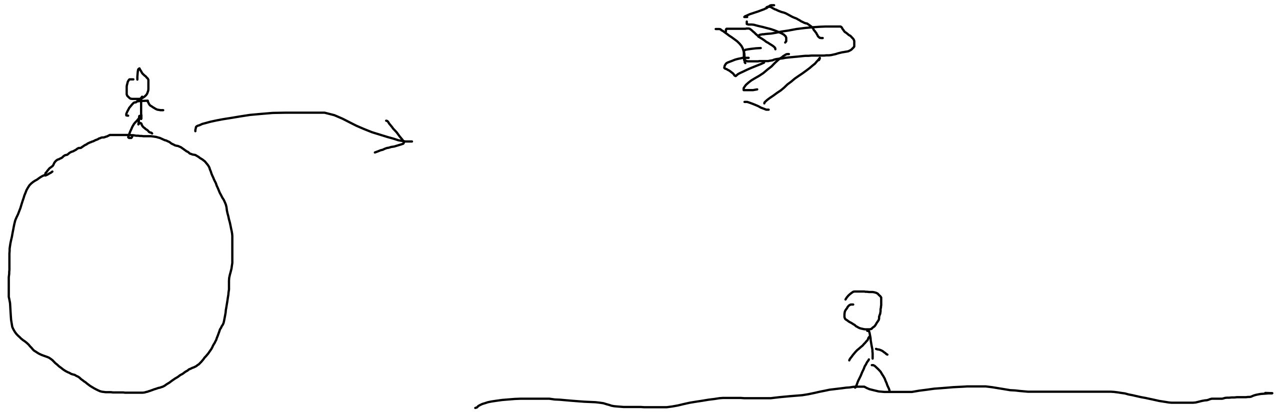
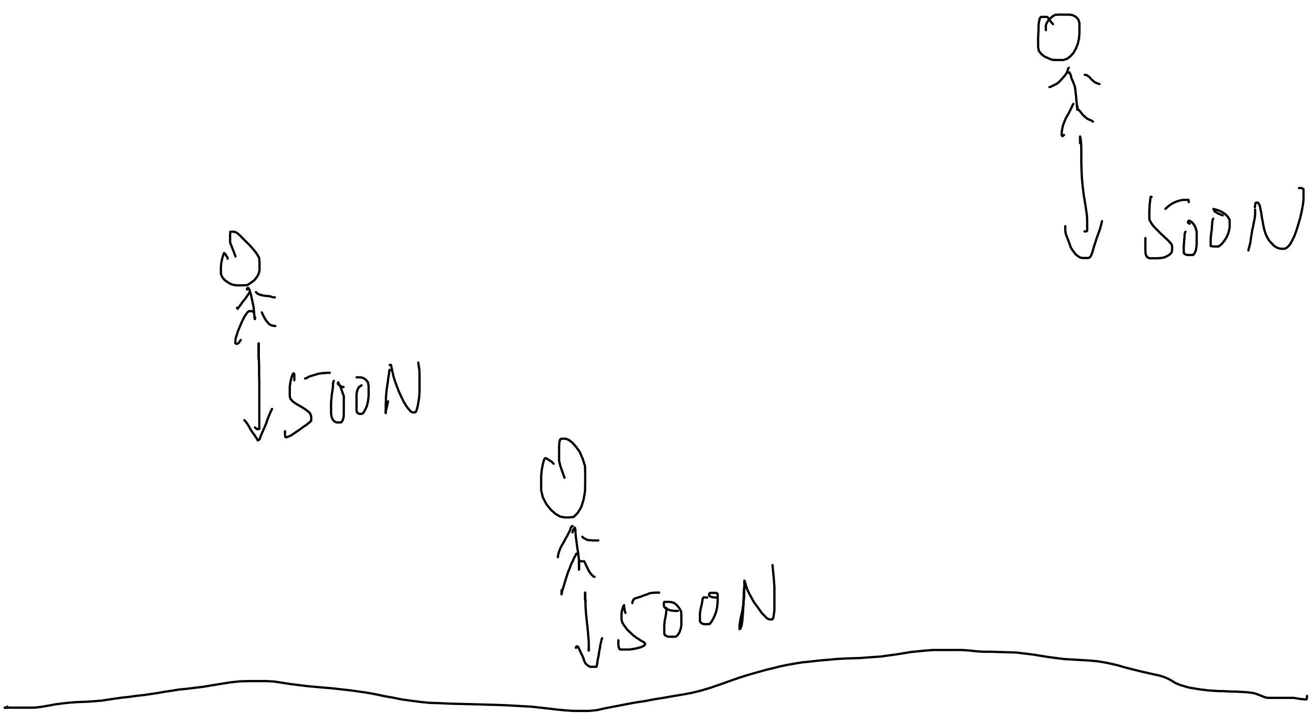


Within a few km of earth's surface, weight stays almost the same.



A uniform field.

derive, from the defining equation W = Fs, the formula E_p = mgh for potential energy changes near the Earth's surface

Potential Energy

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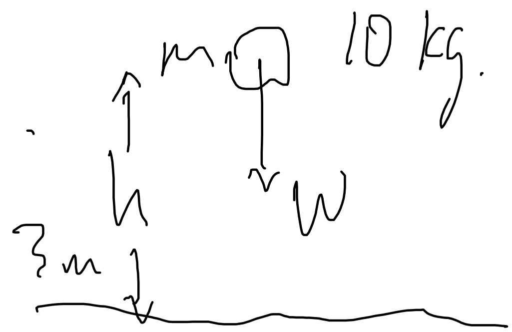
Weight = mass × acceleration due to gravity

$= mg$

$g = 9.81\ m/s^2$

e.g.



$W = mg$

$= 10 \times 9.81$

$= 98.1\ N$

When dropped to ground, work done by gravity

$= Fs$

$= W \times h$

$= mgh = 10 \times 9.81 \times 3$

$= 294.3\ J.$

Potential energy $PE = mgh$

define power as work done per unit time and derive power as the product of force and velocity.

Power

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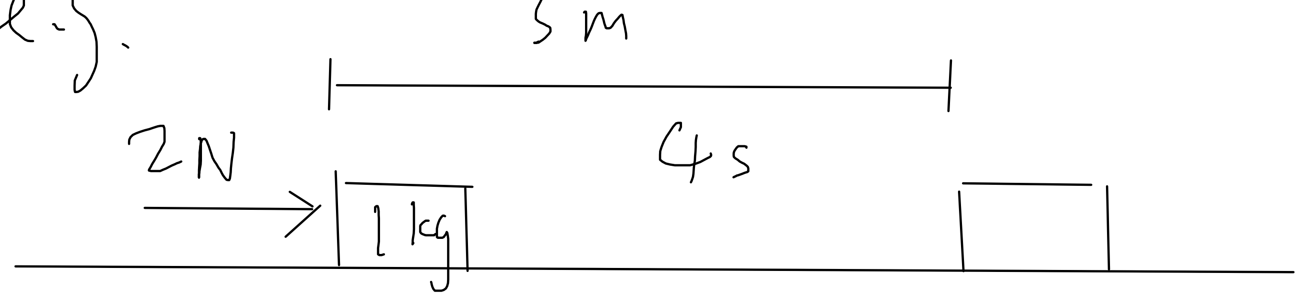
$$\text{Power} = \frac{\text{work done}}{\text{time}}$$

$$\text{or} \quad \frac{\text{energy used}}{\text{time}}$$

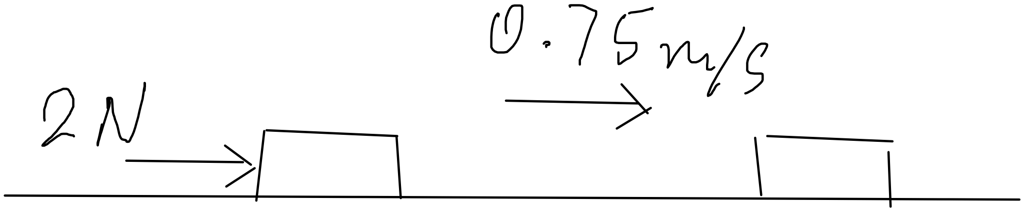
e.g.



$$\text{Power} = \frac{\text{Work}}{\text{time}} = \frac{2 \times 3}{4} = 1.5\,W$$

$$\text{Power} = \frac{Fs}{t} = Fv.$$

e.g.



$$\text{Power} = Fv = 2 \times 0.75 = 1.5\,W$$