Work, Energy, Power

Work

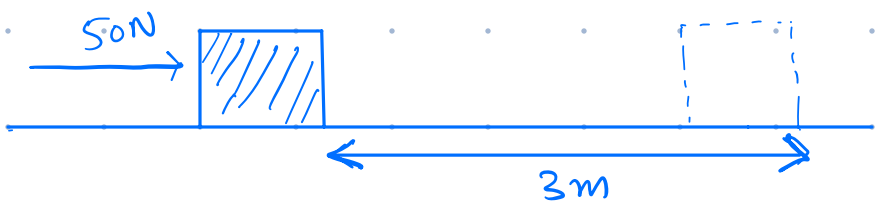
"Product of force and displacement in the direction of force"

$$\text{Work} = \text{Force} \times \text{displacement}$$

- SI unit of work is Nm or Joules (J)
- Work is a scalar quantity

* Work is done when there is an energy transfer, Work done is a measure of the amount of energy transferred

1 Joule = 1 Newton x 1 meter





work done = 50N x 3m = 150 J

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Example: A wooden block is pulled horizontally by 100 N force through a distance of 5m. If there is 30 N frictional force. Find useful work done on the block.

Sol

Total Work done = $100 \times 5 = 500\ J$

lost due to friction = $30 \times 5 = 150\ J$

$\therefore$ useful work done = $500\ J - 150\ J$

$= 350\ J$

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Energy

Ability to do work

" Energy may be stored as Kinetic, gravitational potential, chemical, elastic, nuclear, electrostatic and internal or Thermal"

* A moving object has Kinetic Energy
* Food, fuels (oil, gas, coal, wood), Car batteries store chemical Energy
* A body raised above ground level has gravitational potential energy
* A compressed object such as Spring, football etc have elastic (strain) energy
* Charged objects store electrostatic energy
* energy stored in the nucleus of an atom is nuclear energy which is released when Fission or Fusion reactions take place

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Energy Transfers

Examples

(1) A person riding bicycle



(2) A ball dropped from a height and hits the ground.



(3) Hydroelectric Power station (electricity is produced in a dam)



* Renewable energy Sources: energy from wind, Solar energy, hydroelectricity

* Non-Renewable energy Sources: fossil fuels, nuclear energy

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$$\text{Kinetic Energy} = \frac{1}{2} m v^2 \quad (v \text{ is speed})$$

$$\text{gravitational P.E} = mgh \quad (h \text{ is vertical height})$$

Example

A stone of mass m is dropped from 20 m height, find the speed at which it hits the ground (ignore air resistance)

Sol

$$\text{gravitational P.E} = \text{Kinetic Energy}$$

$$mgh = \frac{1}{2} m v^2$$

$$\sqrt{2gh} = v$$

$$\sqrt{2 \times 9.81 \times 20} = v$$

$$v = 19.8 \text{ ms}^{-1}$$

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Law of Conservation of Energy

"Energy can neither be created nor be destroyed, it can be transferred from one form to another"

generally, in every process:

Total input energy = useful output + Wasted energy

$$\% \text{ efficiency} = \frac{\text{useful output}}{\text{total input}} \times 100$$

Power

"energy transfer per unit time"

OR "Work done per unit time"

$$\text{Power} = \frac{\text{Work done}}{\text{time}} \text{ or } \frac{\text{energy}}{\text{time}}$$

$$\Rightarrow \text{energy} = \text{Power} \times \text{time}$$

* Power is Scalar Quantity, SI unit Watt (Joule per second)

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Past Paper questions

QUESTION # 1: M/J 16 P11

12 What uses non-renewable energy?

limited supply

A a geothermal heating system

B a nuclear power station

C a solar panel

D a wind turbine

QUESTION # 2: M/J 16 P11

13 Which process in the Sun produces energy?

A burning

B nuclear fission

C nuclear fusion

D radiation

QUESTION # 3: M/J 17 P12

16 Which energy source is non-renewable?

A nuclear energy

B solar energy

C tidal energy

D wind energy

QUESTION # 4: M/J 17 P12

17 In a coal-fired power station, the coal is burnt and thermal energy (heat) is produced. The thermal energy is used to produce electrical energy.

In which order does the energy pass through parts of the power station?

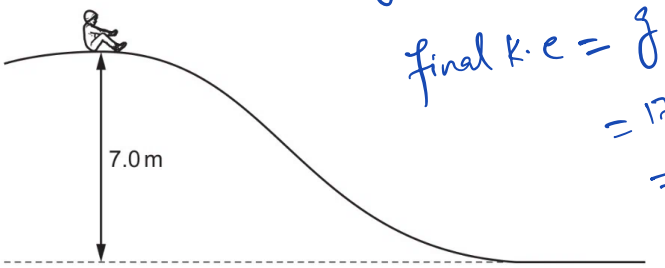
A boiler → generator → turbine

B boiler → turbine → generator

C turbine → boiler → generator

D turbine → generator → boiler

11 A child slides down a slide.



g.p.e = 250 × 7 = 1750 J

final k.e = g.p.e − lost due to friction

= 1750 − 1300

= 450 J

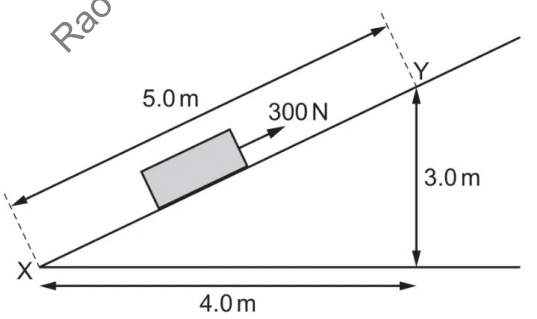
The weight of the child is 250 N. The height of the slide is 7.0 m. The work done against friction as the child travels down the slide is 1300 J.

What is the change in gravitational potential energy and what is the final kinetic energy of the child?

	change in gravitational potential energy	final kinetic energy
A	1750	450
B	1750	1750
C	17 500	16 200
D	17 500	17 500

QUESTION # 2: M/J 16 P11

14 A 300 N force is applied to a box to move it up a ramp, as shown.



How much work is done by the force when moving the box from X to Y?

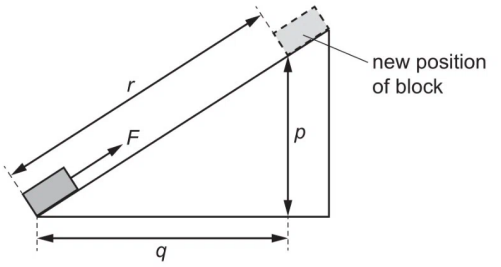
A 900 J **B** 1200 J **C** 1500 J **D** 3000 J

work = force × displacement in same direction

= 300 × 5

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19 The diagram shows a block being pulled up a slope by a force *F*.



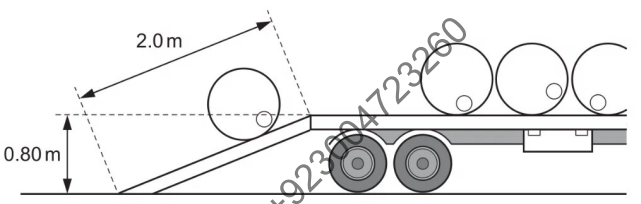
The block reaches the new position at the top of the slope.

What is the work done by force *F* in moving the block to its new position?

A $F \times r$ **B** $F \times p$ **C** $F(q + p)$ **D** $F(r + p)$

QUESTION # 14: O/N 16 P11

8 A workman rolls a barrel of weight 2000 N up a plank of length 2.0 m and onto a lorry. The back of the lorry is 0.80 m above the horizontal surface of the road.



What is the work done on the barrel against gravity?

A 1000 J **B** 1600 J **C** 2500 J **D** 4000 J

work done against gravity = g.p.e = mgh
= wxh
= 2000 x 0.8

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2 **(a)** Fig. 4.1 shows the energy transfers in a lamp.

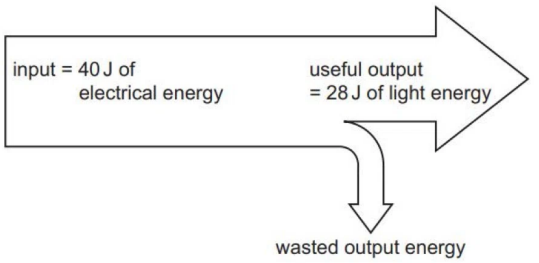


Fig. 4.1 (not to scale)

40J - 28J

(i) State the value of the wasted output energy.

wasted output energy = 12 J [1]

(ii) The energy that is wasted is transferred to an energy store. State the energy store that is increased by the wasted energy.

Thermal energy [1]

(b) A 15 W lamp is switched on for 5.0 minutes.

Calculate the electrical work done in the lamp circuit during this time.

Power x time = 15 W x 5 x 60 Sec

electrical energy supplied = 4500 J [4]

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9 A student holds a pile of books. The mass of the books is 3.2 kg.

(a) Calculate the weight of the books.

$N = mg = 3.2 \times 9.8$

weight = 31.4 N [2]

(b) The student carries the books from the bottom to the top of the stairs shown in Fig. 4.1.

The vertical height of the stairs is 4.5 m.

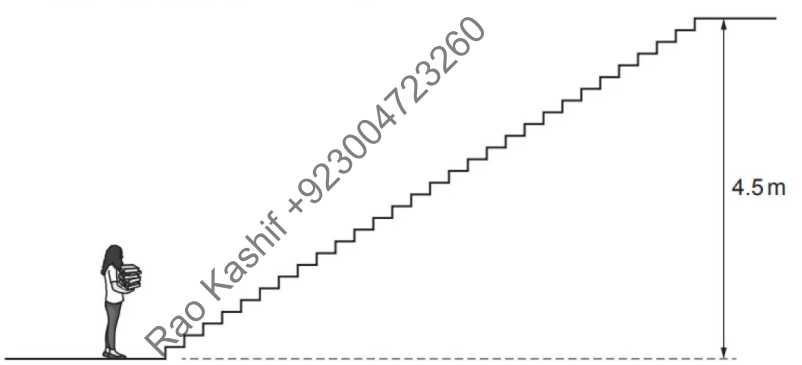


Fig. 4.1

(i) Show that the work done on the books when they are carried to the top of the stairs is approximately 140 J.

$mgh = 3.2 \times 9.8 \times 4.5 = 141.4\ J$

[3]

(ii) Determine the gravitational potential energy gained by the books.

Give a reason for your answer.

gravitational potential energy = 141.4 or 140 J

reason it is work done against gravity

[2]

[Total: 7]

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