Questions complied by Leong Yee Pak

Work, Energy & Power

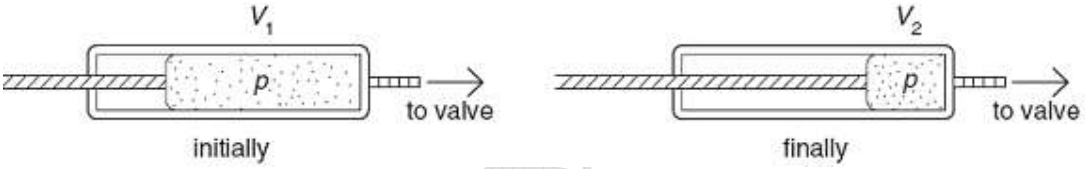
Section A

6.1 Energy conversion and conservation
6.2 Work
6.3 Potential energy, kinetic energy and internal energy
6.4 Power

Work and Energy

****1 June 02 P1 Q17**

Air in a bicycle pump is forced through a valve at a constant pressure p. In one stroke of the pump the volume of air in the pump chamber is reduced from V_1 to V_2.



What is the work done on this air in one stroke of the pump?

A $\frac{p(V_1 + V_2)}{2}$

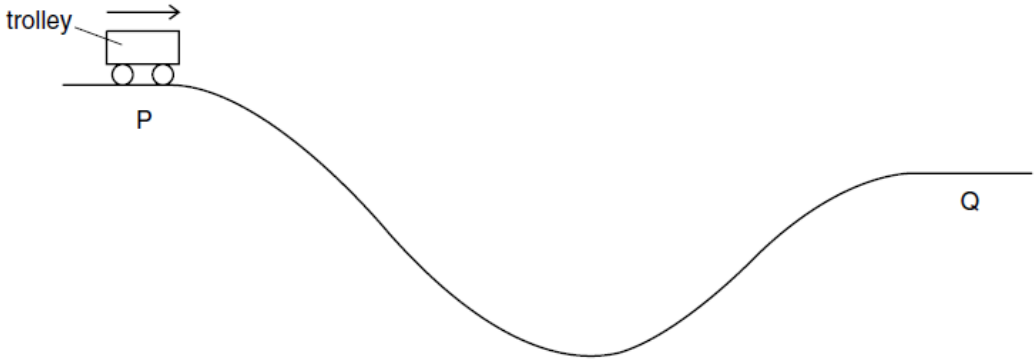
B $p(V_1 + V_2)$

C $p(V_1 - V_2)$

D pV_1

****2 June 02 P1 Q18**

18 A trolley runs from P to Q along a track. At Q its potential energy is 50 kJ less than at P.



At P, the kinetic energy of the trolley is 5 kJ. Between P and Q the work the trolley does against friction is 10 kJ.

What is the kinetic energy of the trolley at Q?

A 35 kJ

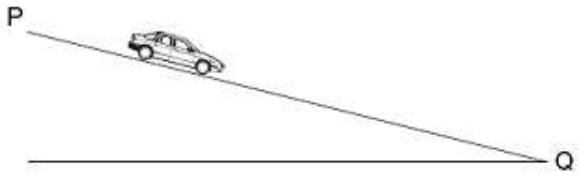
B 45 kJ

C 55 kJ

D 65 kJ

***3 Nov 02 P1 Q17**

A car driver adjusts the pressure on a car's brakes so that the car travels at constant speed down a hill from P to Q.



The magnitude of the change in the car's kinetic energy is ΔE_k. The magnitude of the change in its gravitational potential energy is ΔE_p.

Which statement is correct?

A $\Delta E_k > \Delta E_p$ B $\Delta E_k = \Delta E_p$ C $\Delta E_p > \Delta E_k > 0$ D $\Delta E_k = 0$

****4 Nov 02 P1 Q19**

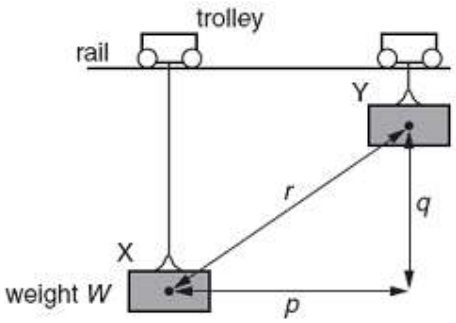
A twig from a tree drops from a 200 m high cliff on to a beach below. During its fall, 40% of the twig's energy is converted into thermal energy.

What is the speed with which the twig hits the beach?

A $35\,m\,s^{-1}$ B $40\,m\,s^{-1}$ C $49\,m\,s^{-1}$ D $63\,m\,s^{-1}$

****5 June 03 P1 Q17**

A weight *W* hangs from a trolley that runs along a rail. The trolley moves horizontally through a distance *p* and simultaneously raises the weight through a height *q*.



As a result, the weight moves through a distance r from X to Y. It starts and finishes at rest.

How much work is done on the weight during this process?

A Wp **B** $W(p + q)$ **C** Wq **D** Wr

****6 June 03 P1 Q18**

18 A motorist travelling at 10 m s^{-1} can bring his car to rest in a distance of 10 m.
If he had been travelling at 30 m s^{-1}, in what distance could he bring the car to rest using the same braking force?

A 17 m **B** 30 m **C** 52 m **D** 90 m

****7 Nov 03 P1 Q17**

A mass is raised vertically. In time t, the increase in its gravitational potential energy is E_p and the increase in its kinetic energy is E_k.

What is the average power input to the mass?

A $(E_p - E_k)t$

B $(E_p + E_k)t$

C $\frac{E_p - E_k}{t}$

D $\frac{E_p + E_k}{t}$

****8 June 04 P Q16**

A ball is thrown vertically upwards.

Neglecting air resistance, which statement is correct?

A The kinetic energy of the ball is greatest at the greatest height attained.

B By the principle of conservation of energy, the total energy of the ball is constant throughc its motion.

C By the principle of conservation of momentum, the momentum of the ball is constant throughout its motion.

D The potential energy of the ball increases uniformly with time during the ascent.

**9 June 04 P1 Q17

Car X is travelling at half the speed of car Y. Car X has twice the mass of car Y.

Which statement is correct?

A Car X has half the kinetic energy of car Y.

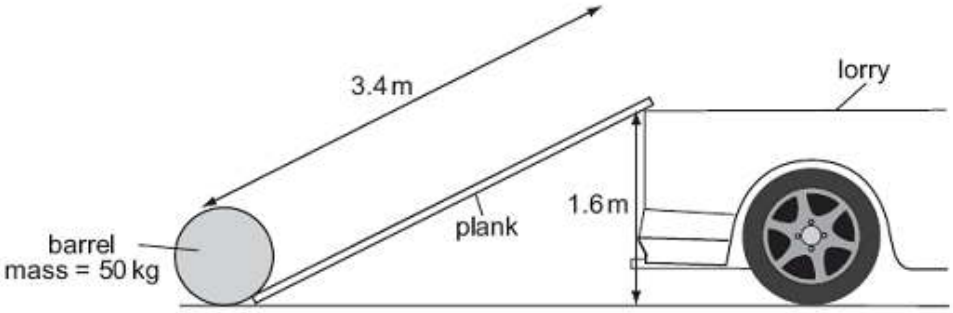
B Car X has one quarter of the kinetic energy of car Y.

C Car X has twice the kinetic energy of car Y.

D The two cars have the same kinetic energy.

**10 June 04 P1 Q18

A barrel of mass 50 kg is loaded onto the back of a lorry 1.6 m high by pushing it up a smooth plank 3.4 m long.



What is the minimum work done?

A 80 J **B** 170 J **C** 780 J **D** 1700 J

**11 Nov 04 P1 Q15

The kinetic energy of a particle is increased by a factor of 4.

By what factor does its speed increase?

A 2 **B** 4 **C** 8 **D** 16

**12 Nov 04 P1 Q16

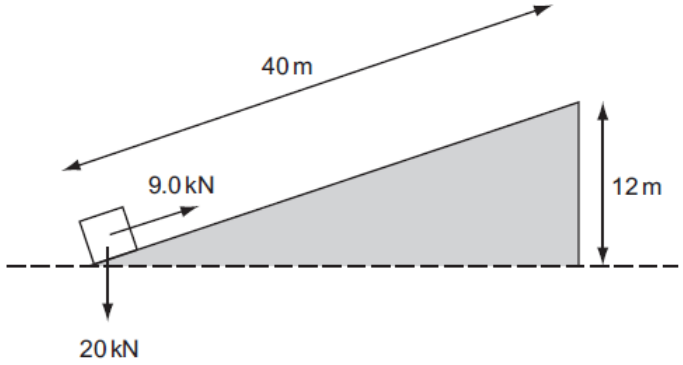
A horizontal force of 90 N is used to push a box across a horizontal floor. The frictional force on the box is 50 N.

What is the gain in kinetic energy of the box when it is moved through a distance of 6.0 m?

A 240 J **B** 300 J **C** 540 J **D** 840 J

**13 Nov 04 P1 Q18

18 A constant force of 9.0 kN, parallel to an inclined plane, moves a body of weight 20 kN through a distance of 40 m along the plane at constant speed. The body gains 12 m in height, as shown.



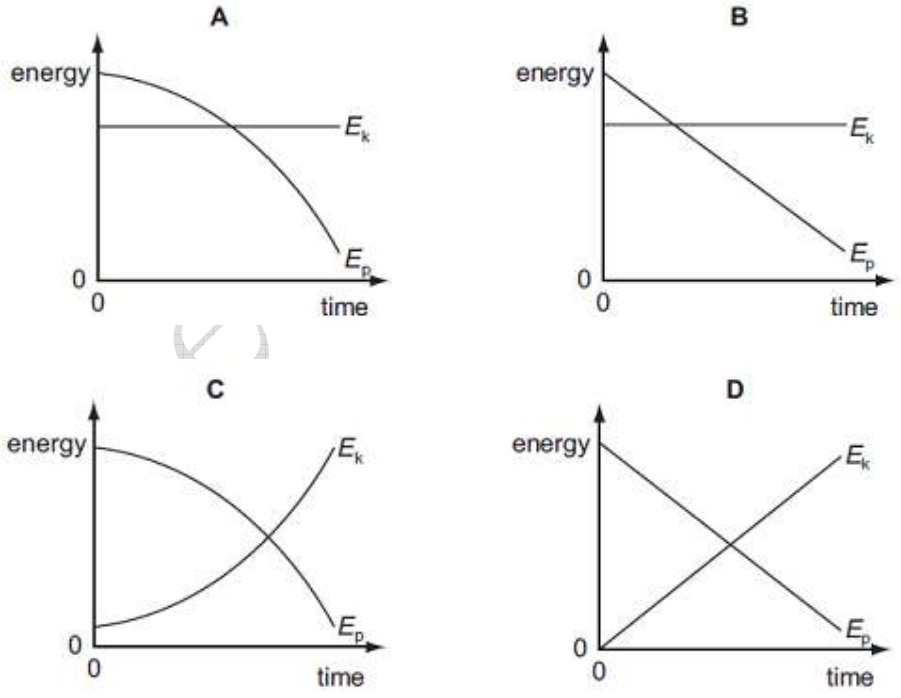
How much of the work done is dissipated as heat?

A 120 kJ B 240 kJ C 360 kJ D 600 kJ

**14 June 05 P1 Q15

A steel ball is falling at constant speed in oil.

Which graph shows the variation with time of the gravitational potential energy E_p and the kinetic energy E_k of the ball?



**15 June 05 P1 Q17

A concrete cube of side 0.50 m and uniform density 2.0 x 10^3 kg m^{-3} is lifted 3.0 m vertically by a crane.

What is the change in potential energy of the cube?

A 0.75 kJ B 7.4 kJ C 29 kJ D 470 kJ

**16 Nov 05 P1 Q14

A car with a total mass of 1400 kg is travelling at 30 $m s^{-1}$.

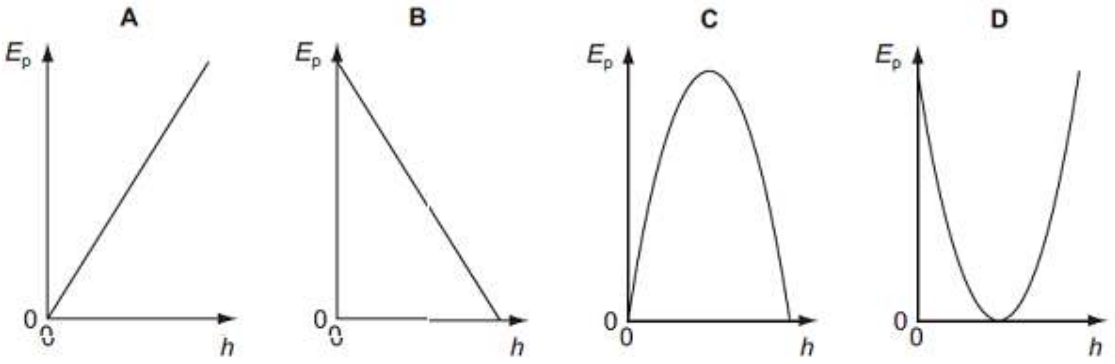
What is the kinetic energy of the car?

A 21 kJ B 42 kJ C 630 kJ D 1260 kJ

***17 Nov 05 P1 Q15

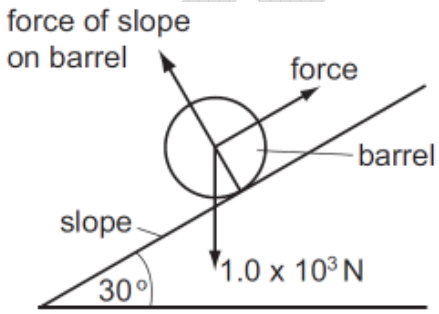
An object is thrown into the air.

Which graph shows how the potential energy E_p of the object varies with height h above the ground?



**18 Nov 05 P1Q16

16 The diagram shows a barrel of weight 1.0 x 10^3 N on a frictionless slope inclined at 30 ° to the horizontal.



A force is applied to the barrel to move it up the slope at constant speed. The force is parallel to the slope.
What is the work done in moving the barrel a distance of 5.0 m up the slope?

A 1.0 x 10^4 J B 2.5 x 10^3 J C 4.3 x 10^3 J D 5.0 x 10^3 J

***19 Nov 06 P1 Q16**

16 What is the internal energy of an object?

A It is the energy associated with the object's movement through space.

B It is the energy associated with the random movement of the molecules in the object.

C It is the energy due to the attractions between the molecules within the object.

D It is the sum of all the microscopic potential and kinetic energies of the molecules.

****20 June 06 P1 Q17**

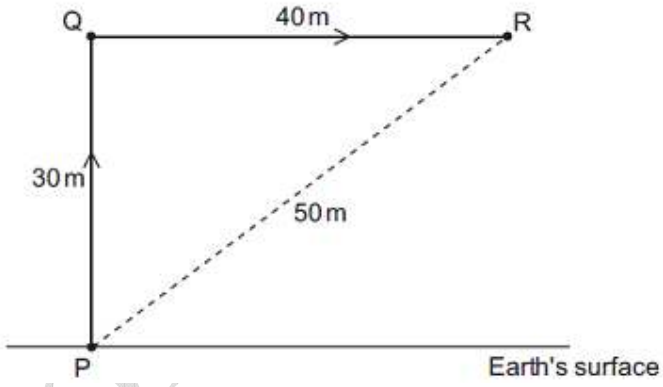
17 A motorist travelling at $10\,m\,s^{-1}$ can bring his car to rest in a braking distance of 10 m.

In what distance could he bring the car to rest from a speed of $30\,m\,s^{-1}$ using the same braking force?

A 17 m **B** 30 m **C** 52 m **D** 90 m

*****21 June 06 P1 Q18**

A stone of weight 4.0 N in the Earth's gravitational field is moved from P to Q and then to R along the path shown.



How much potential energy does the stone gain?

A 120 J **B** 200 J **C** 280 J **D** 1200 J

****22 Nov 06 P1 Q16**

To get to his office from the entrance of the building, a man has to walk up six flights of stairs. The height of each flight is 2.5 m and the man has a mass of 80 kg.

What is the approximate gain in the man's gravitational potential energy during the climb?

A 1200 J **B** 2000 J **C** 4800 J **D** 12 000 J

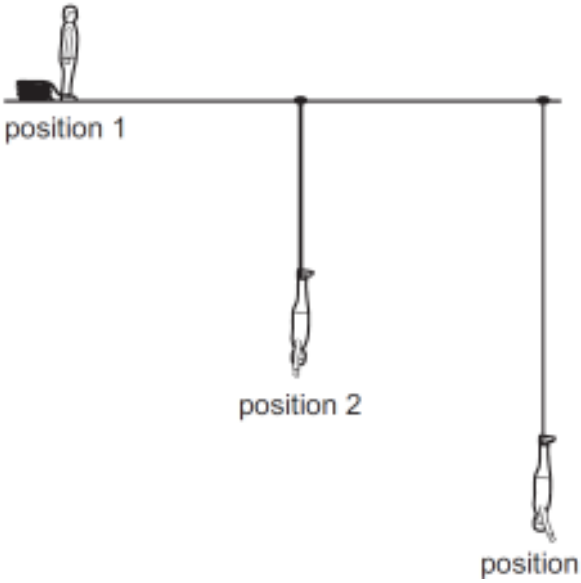
**23 Nov 07 P1 Q15

15 A car of mass 1000 kg first travels forwards at 25 m s^{-1} and then backwards at 5 m s^{-1}. What is the change in the kinetic energy of the car?

A 200 kJ B 300 kJ C 325 kJ D 450 kJ

*24 Nov 07 P1 Q16

16 When bungee jumping, a student starts with maximum gravitational potential energy (position 1), then falls freely until the rope fully unwinds (position 2), after which the rope starts to stretch until the lowest point of the jump is reached (position 3).

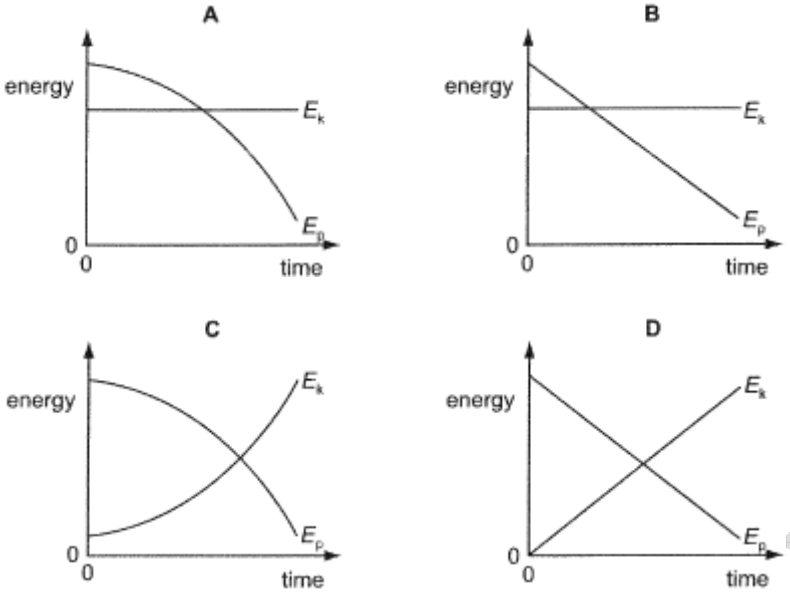


What are the kinetic and elastic potential energies at position 3?

	kinetic energy	elastic potential energy
A	maximum	maximum
B	maximum	minimum
C	minimum	maximum
D	minimum	minimum

***25 June 08 P1 Q18

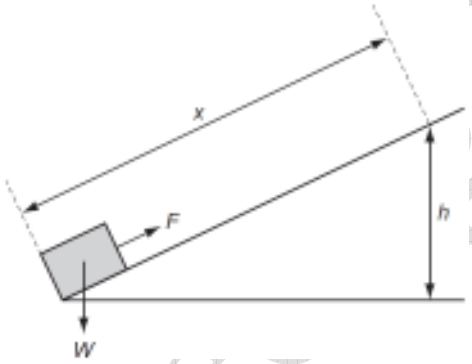
A steel ball is falling at constant speed in oil.
Which graph shows the variation with time of the gravitational potential energy E_p and the kinetic energy E_k of the ball?



**26 Nov 08 P1 Q15

15 A block of weight W is pulled up a rough slope by a force F.

When the block has moved a distance x along the slope, it has risen height h.



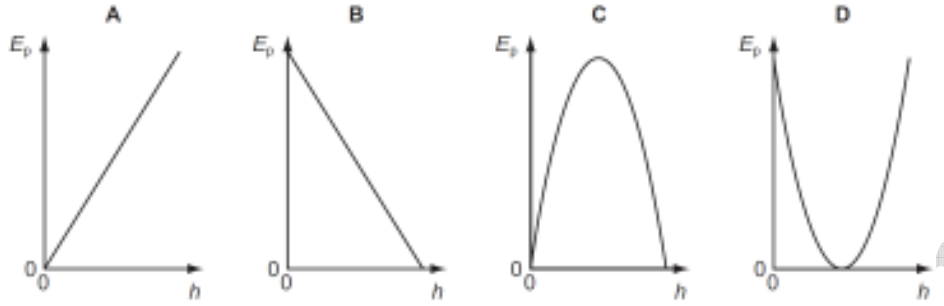
Which expressions give the amount of work done on the block and the amount of gravitational potential energy gained by the block?

	work done	gravitational potential energy
A	Fx	Wh
B	Fh	Wx
C	Wx	Fh
D	Wh	Fx

**27 Nov 08 P1 Q16

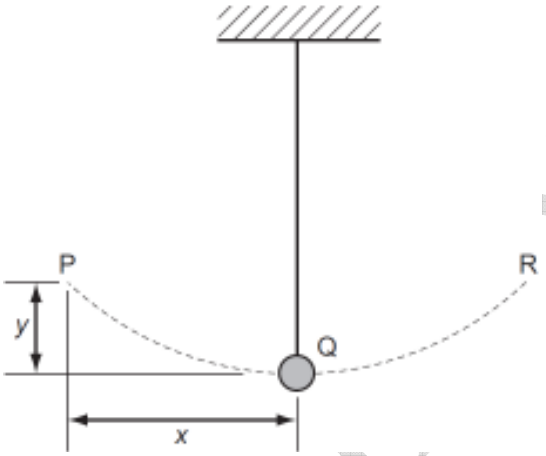
16 An object is thrown into the air.

Which graph shows how the potential energy E_p of the object varies with height h above the ground?



**28 Nov 08 P1 Q17

17 A pendulum bob oscillates between P and R.

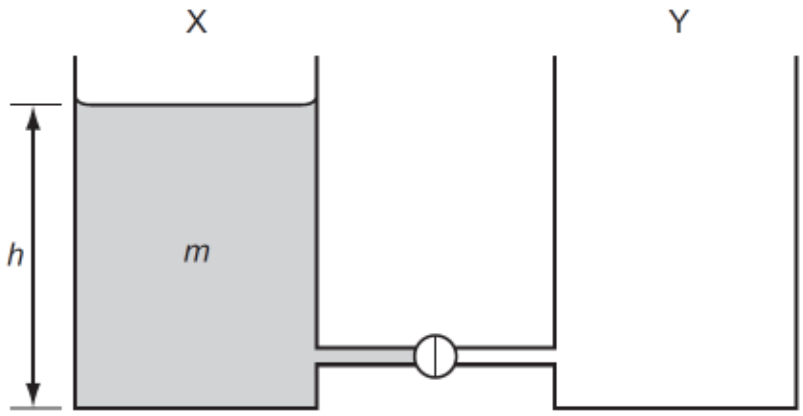


Assuming the gravitational potential energy lost in moving from P to Q is converted into kinetic energy, what is the speed of the bob at Q?

A $\sqrt{2gx}$ **B** $2gx$ **C** $\sqrt{2gy}$ **D** $2gy$

***29 June 09 P1 Q15

15 The diagram shows two identical vessels X and Y connected by a short pipe with a tap.



Initially, X is filled with water of mass m to a depth h, and Y is empty.

When the tap is opened, water flows from X to Y until the depths of water in both vessels are equal.

How much potential energy is lost by the water during this process? (g = acceleration of free fall)

A 0 **B** $\frac{mgh}{4}$ **C** $\frac{mgh}{2}$ **D** mgh

Section B

1 June 02 P2 Q5

Some gas is contained in a cylinder by means of a moveable piston, as illustrated in Fig. 5.1.

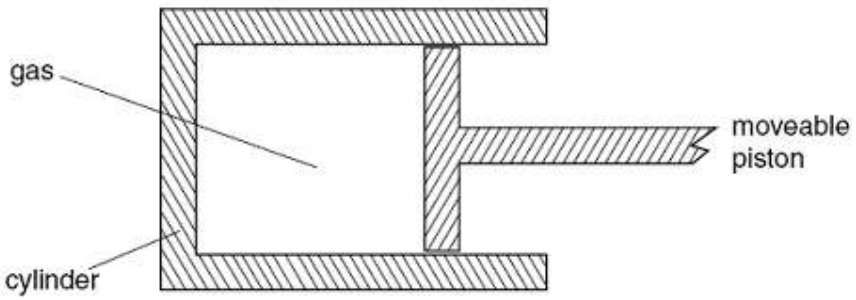


Fig. 5.1

State how, for this mass of gas, the following changes may be achieved.

(a) increase its gravitational potential energy

.....[1]

(b) decrease its internal energy

.....

.....[1]

(c) increase its elastic potential energy

.....

.....[1]

2 Nov 02 P2 Q4

(a) Explain what is meant by the concept of *work*.

.....

.....

.....[2]

(b) Using your answer to **(a)**, derive an expression for the increase in gravitational potential energy ΔE_p when an object of mass m is raised vertically through a distance Δh near the Earth's surface.

The acceleration of free fall near the Earth's surface is g. [2]

3 Nov 05 P2 Q8

(a) Explain the concept of *work*.

.....

.....

..... [2]

(b) A table tennis ball falls vertically through air. Fig. 8.1 shows the variation of the kinetic energy E_K of the ball with distance h fallen. The ball reaches the ground after falling through a distance h_0.

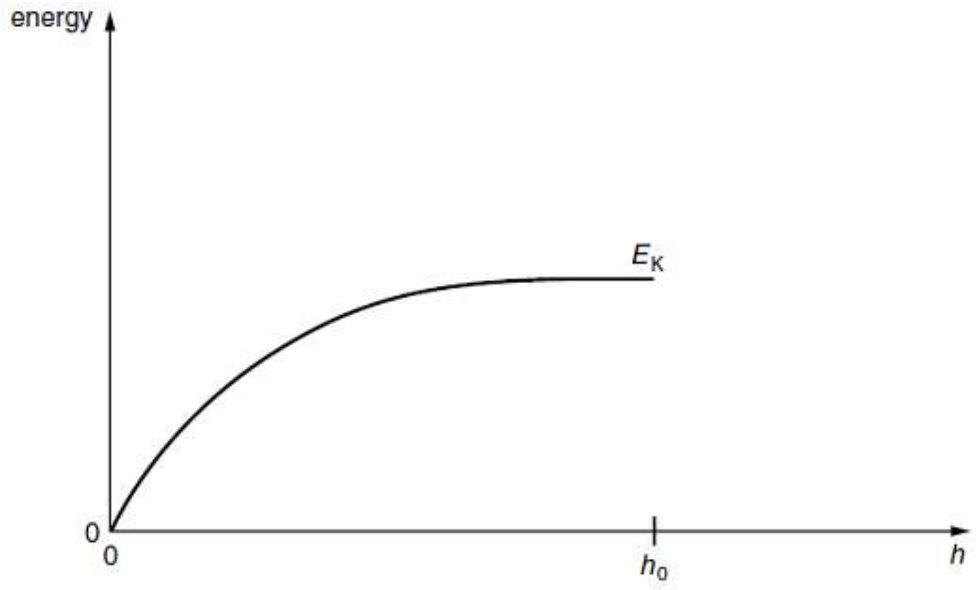


Fig. 8.1

(i) Describe the motion of the ball.

.....

.....

.....

.....

..... [3]

(ii) On Fig. 8.1, draw a line to show the variation with h of the gravitational potential energy E_P of the ball. At $h = h_0$, the potential energy is zero. [3]

4 Nov 07 P2 Q3

3 (a) (i) Define potential energy.

.....

..... [1]

(ii) Distinguish between *gravitational* potential energy and *elastic* potential energy.

gravitational potential energy .....

.....

elastic potential energy .....

..... [2]

(b) A small sphere of mass 51 g is suspended by a light inextensible string from a fixed point P.
The centre of the sphere is 61 cm vertically below point P, as shown in Fig. 3.1.

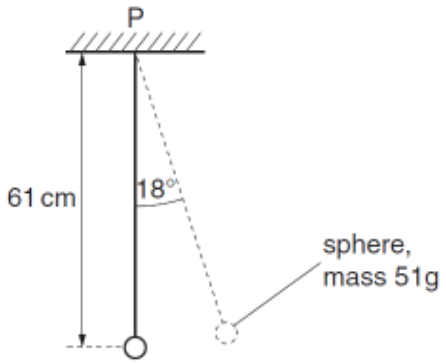


Fig. 3.1

The sphere is moved to one side, keeping the string taut, so that the string makes an angle of 18° with the vertical. Calculate

(i) the gain in gravitational potential energy of the sphere,

gain = ... J [2]

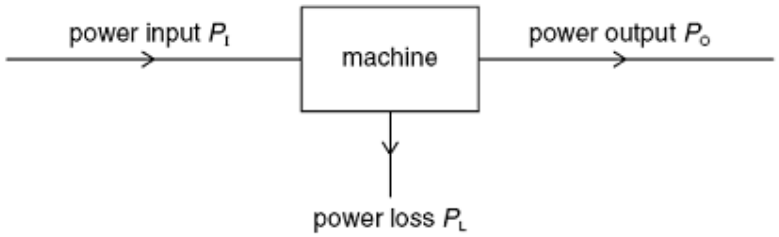
(ii) the moment of the weight of the sphere about point P.

moment = ... N m [2]

Power and Efficiency

***1 June 02 P1 Q16**

Power is transferred through a machine as shown.



What is the efficiency of the machine?

A $\frac{P_I}{P_O + P_L}$ B $\frac{P_L}{P_I}$ C $\frac{P_L}{P_O}$ D $\frac{P_O}{P_I}$

****2 June 02 P1 Q19**

To travel at a constant speed, a car engine provides 24 kW of useful power. The driving force on the car is 600 N.

At what speed does it travel?

A $2.5\,m\,s^{-1}$

B $4.0\,m\,s^{-1}$

C $25\,m\,s^{-1}$

D $40\,m\,s^{-1}$

***3 Nov 02 P1Q16**

16 Which of the following is an expression for power?

A energy x time

B force x displacement

C force x velocity

D mass x velocity

****4 Nov 02 P1 Q18**

18 An area of land is an average of 2.0 m below sea level. To prevent flooding, pumps are used to lift rainwater up to sea level.
What is the minimum pump output power required to deal with 1.3×10^9 kg of rain per day?

A 15 kW **B** 30 kW **C** 150 kW **D** 300 kW

***5 June 03 P1 Q16**
Which of the following expressions **defines** power?

A force x distance moved in the direction of the force

B force x velocity

C work done ÷ time taken

D work done x time taken

***6 Nov 03 P1 Q18**
A boat moving at constant speed v through still water experiences a total frictional drag F.

What is the power developed by the boat?

A $\frac{1}{2}Fv$ **B** Fv **C** $\frac{1}{2}Fv^2$ **D** Fv^2

***7 June 04 P1 Q15**
What is the expression used to **define** power?

A $\frac{\text{energy output}}{\text{energy input}}$

B energy x time taken

C force x velocity

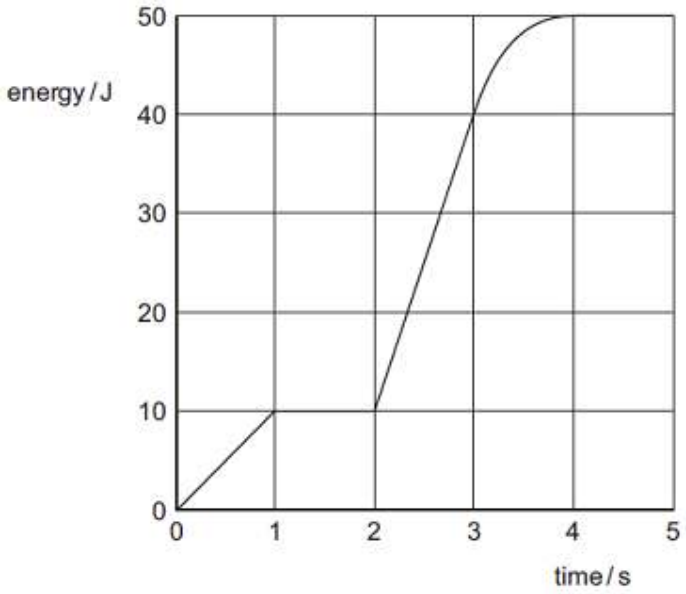
D $\frac{\text{work done}}{\text{time taken}}$

****8 Nov 04 P1 Q17**
A cyclist is capable of generating an average power of 3.0 kW during a 4.0 km speed trial. His aerodynamic suit and position on the cycle reduce resistive forces to 180 N.

What is the approximate time achieved in the speed trial?

A 140 s **B** 240 s **C** 1300 s **D** 2200 s

*****9 June 05 P1 Q16**
An electrical generator is started at time zero. The total electrical energy generated during the first 5 seconds is shown in the graph.



What is the maximum electrical power generated at any instant during these first 5 seconds?

A 10 W **B** 13 W **C** 30 W **D** 50 W

****10 Nov 06 P1 Q17**

In many old-style filament lamps, as much as 93 J of energy is emitted as thermal energy for every 7 J of energy emitted as light.

What is the efficiency of the lamp, as the percentage of electrical energy converted to light energy?

A 7 % **B** 8 % **C** 92 % **D** 93 %

****11 Nov 06 P1 Q18**

An electric railway locomotive has a maximum mechanical output power of 4.0 MW. Electrical power is delivered at 25 kV from overhead wires. The overall efficiency of the locomotive in converting electrical power to mechanical power is 80 %.

What is the current from the overhead wires when the locomotive is operating at its maximum power?

A 130 A **B** 160 A **C** 200 A **D** 250 A

***12 June 07 P1 Q14**

14 Which expression **defines** power?

A force × distance moved in the direction of the force

B force × velocity

C work done ÷ time taken

D work done × time taken

**13 June 08 P1 Q19

The total energy input E_{in} in a process is partly transferred to useful energy output U, and partly to energy that is wasted W.
What is the efficiency of the process?

A $\frac{U}{W} \times 100\,\%$

B $\frac{W}{E_{in}} \times 100\,\%$

C $\frac{U}{E_{in}} \times 100\,\%$

D $\frac{U+W}{E_{in}} \times 100\,\%$

**14 Nov 08 P1 Q18

18 Which operation involves the greatest mean power?

A a car moving against a resistive force of 0.4 kN at a constant speed of 20 m s^{-1}

B a crane lifting a weight of 3 kN at a speed of 2 m s^{-1}

C a crane lifting a weight of 5 kN at a speed of 1 m s^{-1}

D a weight being pulled across a horizontal surface at a speed of 6 m s^{-1} against a frictional force of 1.5 kN

**15 June 09 P1 Q14

14 The forward motion of a motor-boat is opposed by forces F which vary with the boat's speed v in accordance with the relation $F = kv^2$, where k is a constant.

The effective power of the propellers required to maintain the speed v is P.

Which expression relates k, P and v?

A $k = \frac{P}{v}$ B $k = \frac{P}{v^2}$ C $k = \frac{P}{v^3}$ D $k = \frac{P}{v^4}$

Section B

1 Nov 06 P2 Q1

(a) Define what is meant by

(i) *work done*,

.....

.....

..... [2]

(ii) *power*.

.....

..... [1]

(b) A force F is acting on a body that is moving with velocity v in the direction of the force.

Derive an expression relating the power P dissipated by the force to F and v.

[2]

(c) A car of mass 1900 kg accelerates from rest to a speed of 27 m s^{-1} in 8.1 s.

(i) Calculate the average rate at which kinetic energy is supplied to the car during the acceleration.

rate = ... W [2]

(ii) The car engine provides power at a constant rate. Suggest and explain why the acceleration of the car is **not** constant.

.....

.....

..... [2]

2 June 08 P2Q3

3 A shopping trolley and its contents have a total mass of 42 kg. The trolley is being pushed along a horizontal surface at a speed of $1.2\,m\,s^{-1}$. When the trolley is released, it travels a distance of 1.9 m before coming to rest.

(a) Assuming that the total force opposing the motion of the trolley is constant,

(i) calculate the deceleration of the trolley,

deceleration = ... $m\,s^{-2}$ [2]

(ii) show that the total force opposing the motion of the trolley is 16 N.

[1]

(b) Using the answer in **(a)(ii)**, calculate the power required to overcome the total force opposing the motion of the trolley at a speed of $1.2\,m\,s^{-1}$.

power = ... W [2]

(c) The trolley now moves down a straight slope that is inclined at an angle of 2.8° to the horizontal, as shown in Fig. 3.1.

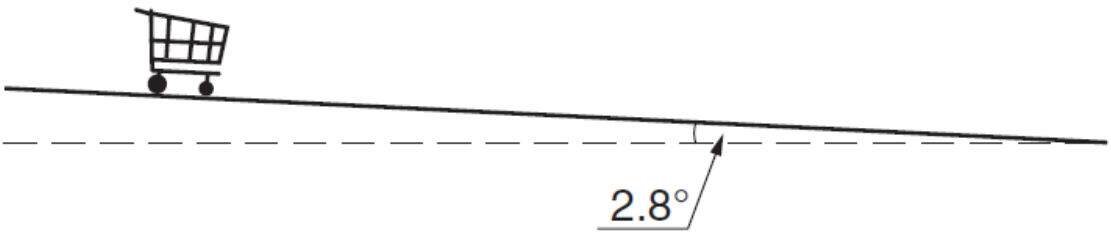


Fig. 3.1

The constant force that opposes the motion of the trolley is 16 N.

Calculate, for the trolley moving down the slope,

(i) the component down the slope of the trolley's weight,

component of weight = ... N [2]

(ii) the time for the trolley to travel from rest a distance of 3.5 m along the length of the slope.

time = ... s [4]

(d) Use your answer to **(c)(ii)** to explain why, for safety reasons, the slope is not made any steeper.

.....

.....[1]