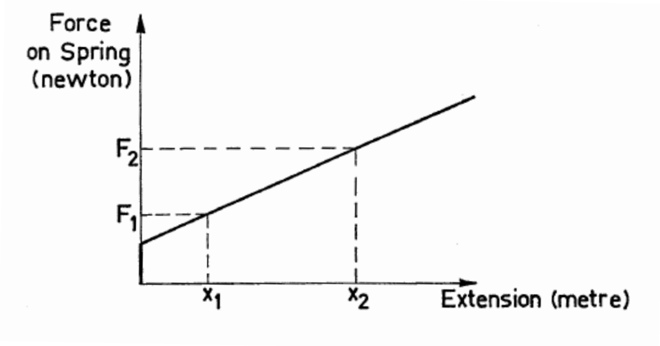
The force-extension graph of a spring is show below.



1970 Question 31, 1 mark 60%

Using only symbols shown above write an expression for k, the force constant of the spring.

The spring constant, k, is the gradient of the line in the linear region.

$$\therefore k = \frac{F_2 - F_1}{x_2 - x_1} \text{ (ANS)}$$

1970 Question 32, 1 mark 21%

The work done in extending the spring from x_1 to x_2 is equal to (one or more answers)

A. $\frac{1}{2}kx_2^2 - \frac{1}{2}kx_1^2$

B. $(F_2 – F_1)(x_2 – x_1)$

C. $\frac{1}{2}(F_2 – F_1)(x_2 – x_1)$

D. $F_2x_2 = F_1x_1$

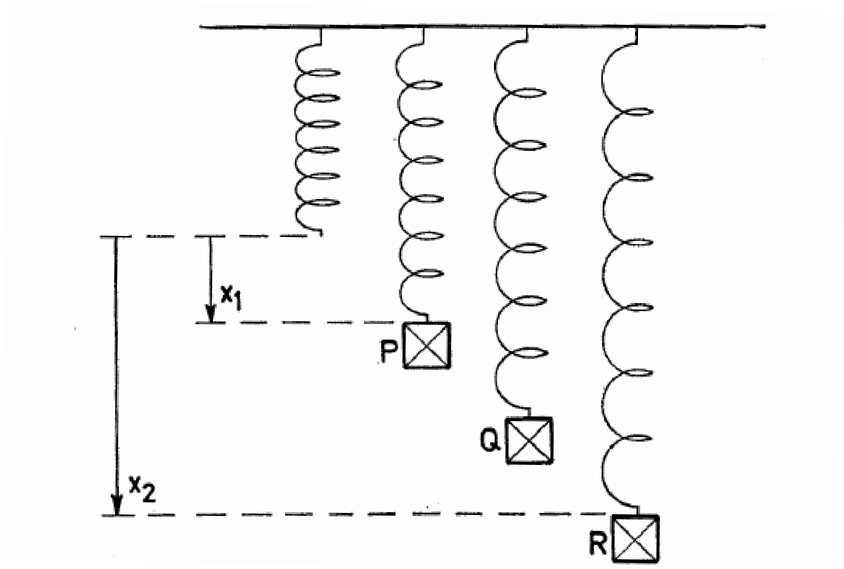
E. $\frac{1}{2}(F_2 + F_1)(x_2 – x_1)$

***A** and **E, A** according to formula for string potential energy, **E** according the energy stored in the spring is given by the area under the force extension graph. This is a trapezium.*

∴ the work done in extending is

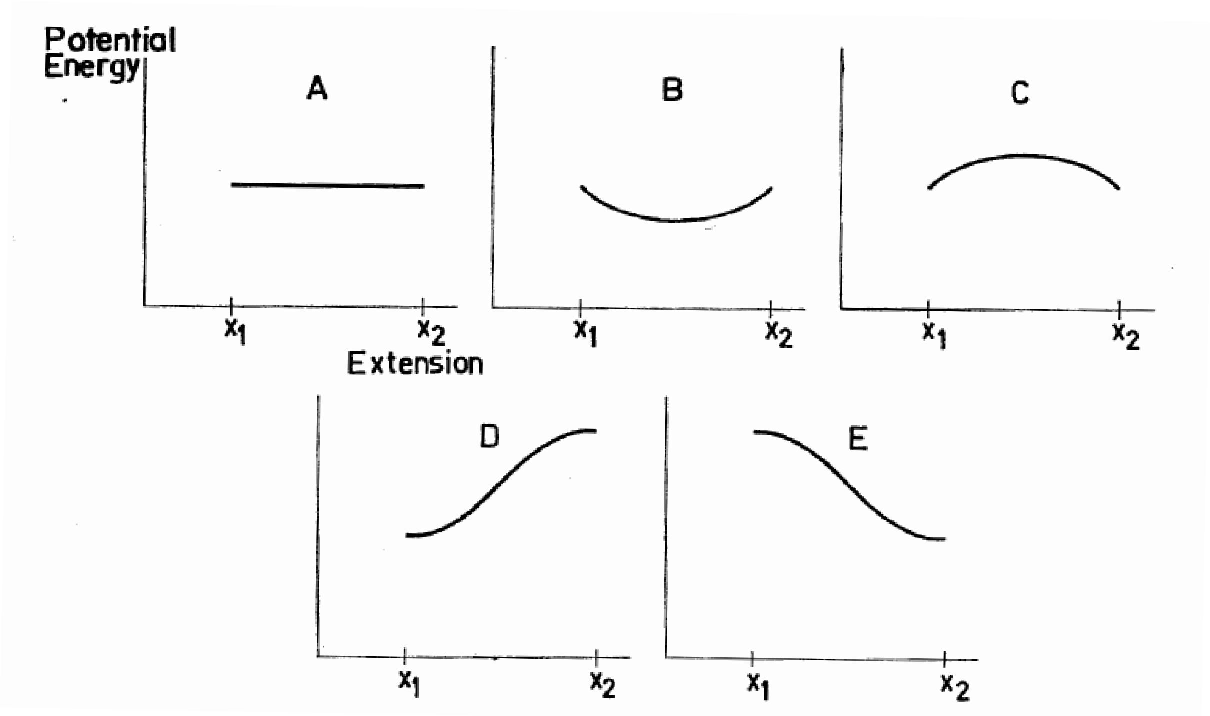
$$\frac{1}{2}(F_1 + F_2)(x_2 – x_1)$$

A mass of m kg is now hung from this spring. The mass is held at, P (at extension x_1) and then released; it passes through a mean position Q, to R (at extension x_2) and then returns. The motion is depicted below.



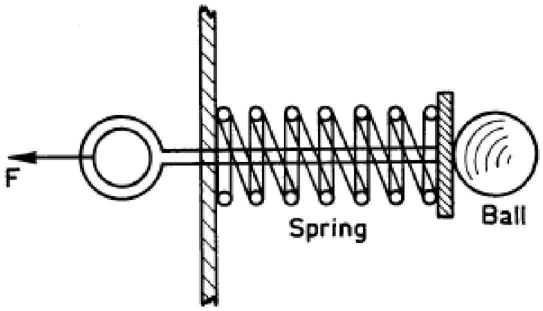
1970 Question 33, 1 mark 28%

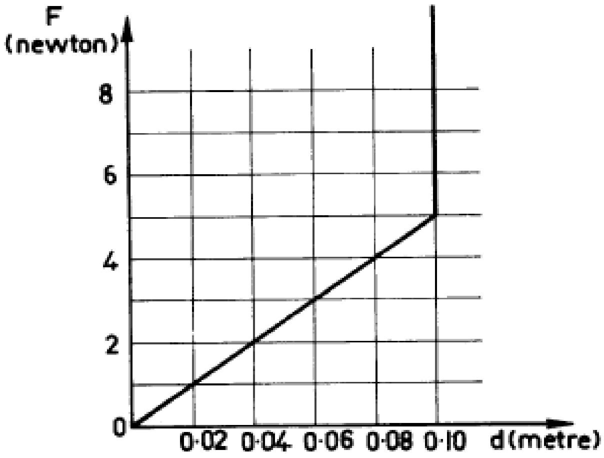
During the motion between P and R which of the following graphs best represents the sum of the potential energy of the spring plus the gravitational potential energy of the mass?



The sum of the gravitational PE and the spring PE and the KE must be constant. The KE graph will be zero at P and R and a maximum at Q. For the total energy to be constant the sum of the potential energy of the spring plus the gravitational potential energy of the mass must look like

*.: **B (ANS)***





In a pinball machine the plunger is pulled to compress the spring.
When it is released, the spring projects the steel ball.
Experiments performed on the mechanism yield the graph of spring displacement *d* against the compressing force *F*.

1973 Question 35, 1 mark 71%

What is the spring constant of the spring before it is fully compressed?

The spring constant is given by the gradient of the graph.

$\therefore k = \dfrac{5}{0.1}$

$\quad\quad \boldsymbol{= 50\ N\ m^{-1}}$ ***(ANS)***

1973 Question 36, 1 mark 64%

How much work is done in compressing the spring to a point where the force is 5.0 Newton?

$WD = \frac{1}{2} k\Delta x^2$

Use the graph to find x when the force = 5.0 N.

$\quad\quad \therefore x = 0.1\ m$

$\therefore \frac{1}{2} k\Delta x^2 = \frac{1}{2} \times 50 \times 0.1^2$

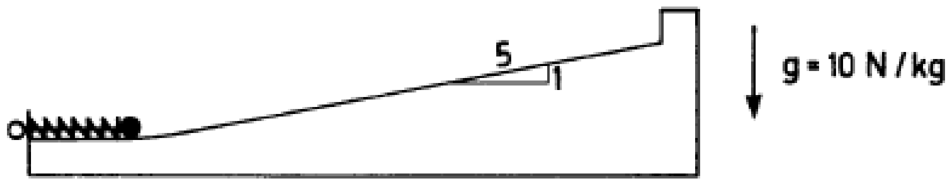
$\quad\quad \boldsymbol{= 0.25\ J}$ ***(ANS)***

1973 Question 37, 1 mark 83%

How much additional work is done in increasing the force to 8.0 Newton?

Increasing the force to 8 N will not alter the compression.

$\therefore$ ***0 J (ANS)***



The above arrangement is used on the pinball table as shown.

1973 Question 38, 1 mark 44%

A ball of mass 0.250 kg is placed on the plunger. The spring is fully compressed and then released. Assuming that the plunger and the spring have negligible mass, what is the velocity, *v*, of the ball when it leaves the plunger?

The graph of the force vs extension graph shows that full compression is when 5 N or 0.1 m. The energy stored in the spring is released as the KE of the ball.

$\therefore 0.25 = \frac{1}{2} mv^2$

$\therefore v^2 = \frac{0.25 \times 0.5}{0.250}$

$\therefore v = \sqrt{\frac{0.25 \times 0.5}{0.250}}$

$\therefore$ $\boldsymbol{v = 1.41\ m\ s^{-1}}$ ***(ANS)***

1973 Question 39, 1 mark 27%

The table has a slope of 1 in 5. How far along the surface of the table could the ball travel? (answer in terms of *v*)

The gain in gravitational PE must equal the loss in KE.

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

$\therefore gh = \frac{1}{2} v^2$

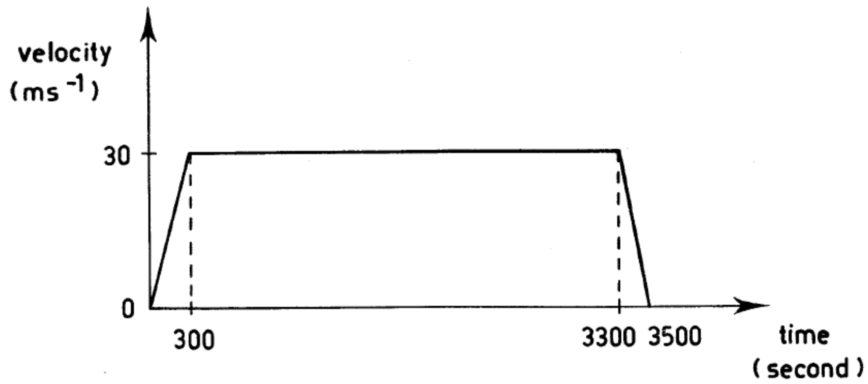
$\therefore h = \frac{v^2}{20}$

The distance the ball travels along the surface is given by 5 × h.

$\therefore d = 5 \times \frac{v^2}{20}$

$\boldsymbol{= \frac{v^2}{4}}$ ***(ANS)***

A train accelerates from rest at one station and travels to another station. The velocity-time graph for the train is shown below. The mass of the train is 5.0 × 10^5 kg. Assume that a constant frictional resistance of 1.5 × 10^4 N acts on the train throughout its journey.



1976 Question 4, 1 mark 24%

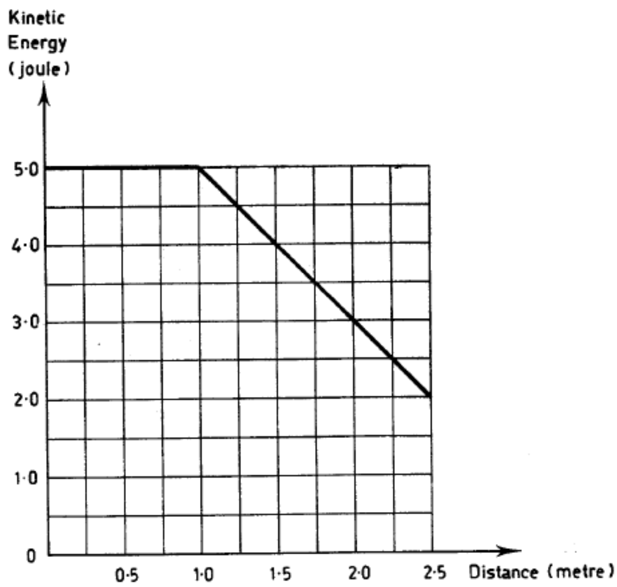
Calculate the power in kilowatt at which the engine works during the period of constant velocity.

Power is the rate of doing work, it is given by the formula P = Fv.
When the train is travelling at a constant speed the engine just needs to overcome the frictional forces.

$\therefore P = 1.5 \times 10^4 \times 30$

$\therefore P = 4.5 \times 10^5$

$\therefore$ ***P = 450 kW (ANS)***



A loaded ice-puck moves on a table 2.5 metre long. 1.0 metre of the table is highly polished; the rest is rough. The graph above shows the kinetic energy of the puck versus distance along the table. The mass of the loaded puck is 5.0 kg.

1976 Question 14, 1 mark 75%

What is the initial velocity of the puck?

Initially the KE = 5 J $\therefore \frac{1}{2}mv^2 = 5 \quad \therefore v^2 = 2 \times 5 \div 5$

$\therefore$ ***v = 1.4 m s***$^{-1}$ ***(ANS)***

1976 Question 15, 1 mark 76%

How much work was done against friction caused by the rough part of the table?

The work done by the friction is given by the change in KE.

$\therefore$ *5 – 2* ***= 3 J (ANS)***

1976 Question 16, 1 mark 72%

What is the magnitude of the frictional force?

Use WD = f × d

$\therefore 3 = F \times 1.5$

$\therefore$ ***F = 2.0 N (ANS)***

1976 Question 17, 1 mark 54%

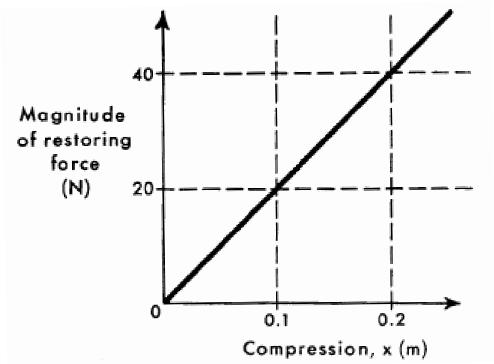
The puck reaches the edge of the table and falls to the floor 1.0 metre below the table. What is the total energy of the puck just before striking the floor?

Same as at the edge of the table. KE = 2 J, GPE = mgh = 5x10x1 = 50 J

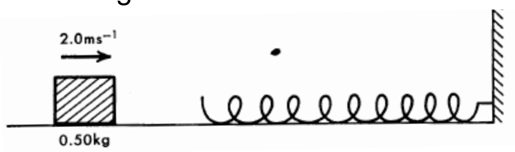
Total ***52 J***

A spring behaves so that the restoring force it exerts is related to the compression by the relationship $F = 200\ x$

Where F is the magnitude of the restoring force (in N) and x is the compression (in m).



A body of mass 0.50 kg travelling at 2.0 m s^{-1} approaches the spring which is fixed to a wall as shown below. Friction can be neglected.



The body comes to rest instantaneously at a time t_1, when the spring is compressed by a total amount x_1, It then rebounds.

1977 Question 21, 1 mark 55%

Calculate the value of x_1.

At x_1, the initial KE of the block is stored as PE of the spring.

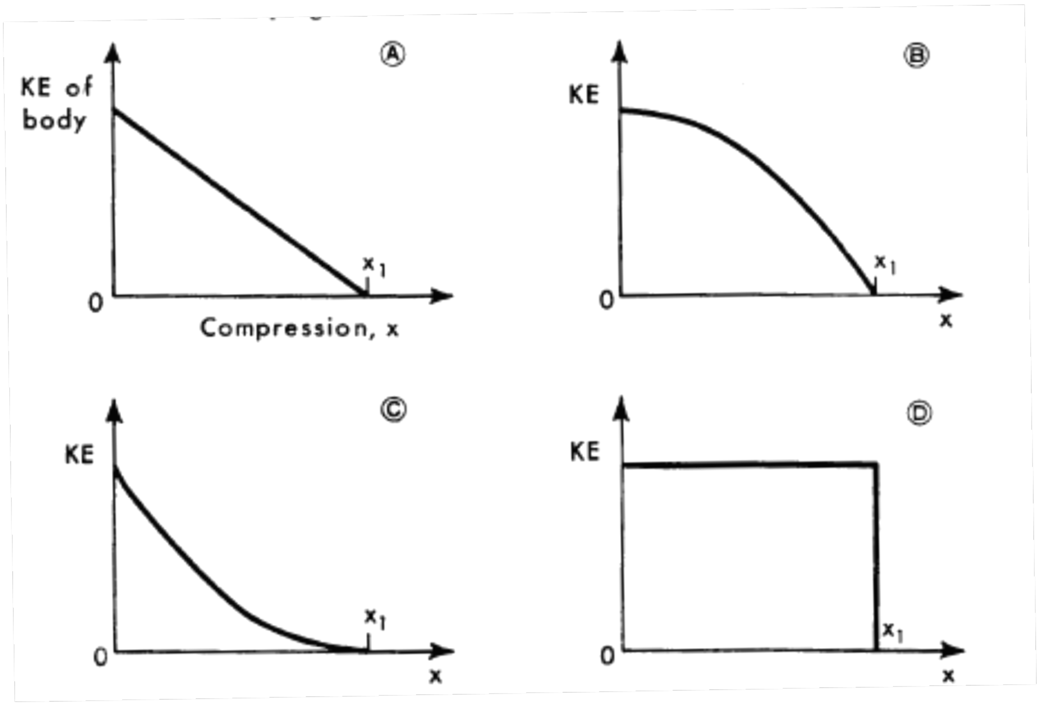
$\therefore \frac{1}{2} mv^2 = \frac{1}{2} k\Delta x^2$

$\therefore 0.5 \times 0.5 \times 2^2 = 0.5 \times 200 \times (x_1)^2$

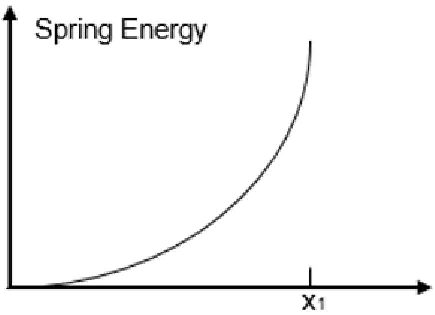
$\therefore x_1 = \sqrt{\frac{1}{100}}$ $\therefore$ $\boldsymbol{x_1 = 0.1}$ ***m (ANS)***

1977 Question 22, 1 mark 45%

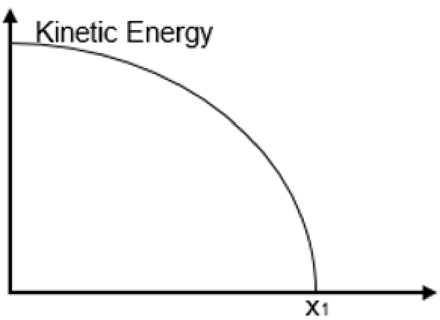
Which of the graphs below best represents the kinetic energy of the body as a function of the compression, x_1 of the spring?



The KE will go from a maximum to a minimum (in this case 0).
It will not be linear.
The sum $KE_{mass} + PE_{spring}$ *= constant.*
The energy stored in the spring is given by
$E = \frac{1}{2} k\Delta x^2$
This will look like

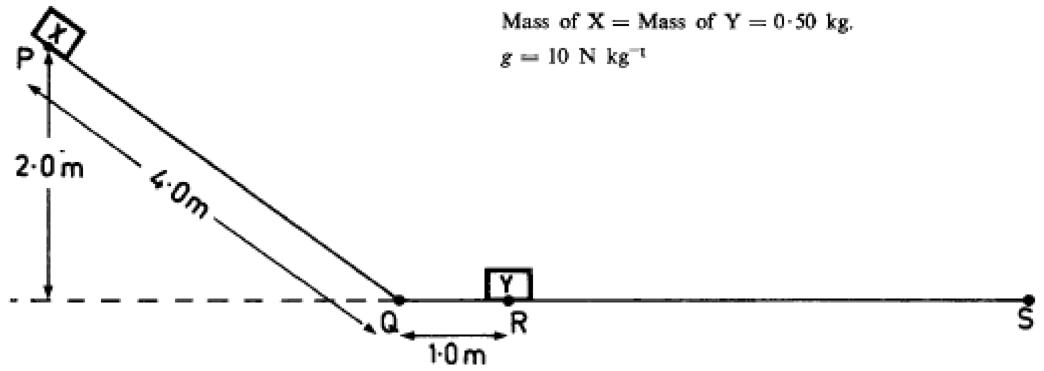


Therefore the KE graph will look like



∴ B (ANS)

Two blocks, X and Y, are at points P and R as shown in the diagram, *which is not to scale.*



X and Y are initially at rest at the positions shown in the diagram.

1978 Question 27, 1 mark 91%

What is the difference between the potential energy of block X and the potential energy of block Y, when they are in their initial positions?

Gravitational PE = mgh.
∴ ΔPE = mgh = 0.5 × 10 × 2 ***= 10 J (ANS)***

X is released and slides down the slope to PQ. *Throughout the surface PQRS,* a constant friction force of 1.0 N acts on X and Y when they are moving.

1978 Question 28, 1 mark 63%

How much work is done against friction as block X slides down PQ?

WD = F × d = 1 × 4 ***= 4 J (ANS)***

1978 Question 29, 1 mark 42%

What is the kinetic energy of block X as it reaches point R?

Block X needs to travel 5 m to Block Y.
∴ it will lose 5J of energy overcoming the frictional force.
Block X starts with 10J at P therefore it will have 10 – 5 = 5J at R.
5 J (ANS)

1978 Question 30, 1 mark 78%

If the collision between X and Y is elastic, what is the kinetic energy of block Y as it leaves point R?

If the collision is elastic, then Block X will be stationary and block Y will have all the energy.
∴ ***5 J (ANS)***

1978 Question 31, 1 mark 62%

If S is the point at which block Y comes to rest, what is the distance RS?

The work done is given by WD = Fd, where the force acting is the frictional force (1.0 N).
∴ WD = 5 = f × d = 1 × d
∴ ***d = 5 m (ANS)***

1978 Question 32, 1 mark 83%

The kinetic energy of the two blocks at the end of their motions is zero, i.e. it is less than the initial potential energy of block X. Which of the following statements provides the best explanation for this?

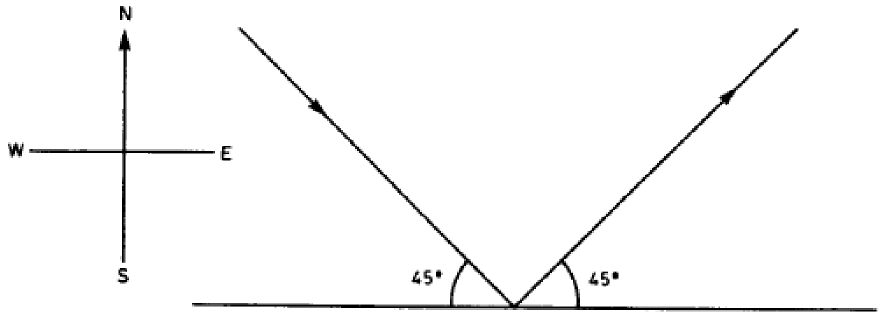
A. Energy is not conserved in this situation.

B. The potential energy of block X has been transformed into forms of energy other than kinetic energy of the blocks.

C. Potential energy is never conserved.

D. Potential energy has been lost because the collision between X and Y was elastic.

The potential energy has been lost overcoming the frictional force.
*∴ **B (ANS)***



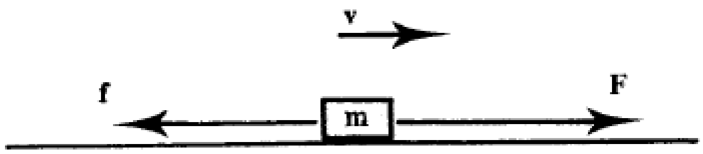
A particle of mass *m*, travelling south-east at constant speed *v*, hits a wall and then travels north-east at the same speed *v*.

1980 Question 16, 1 mark 70%

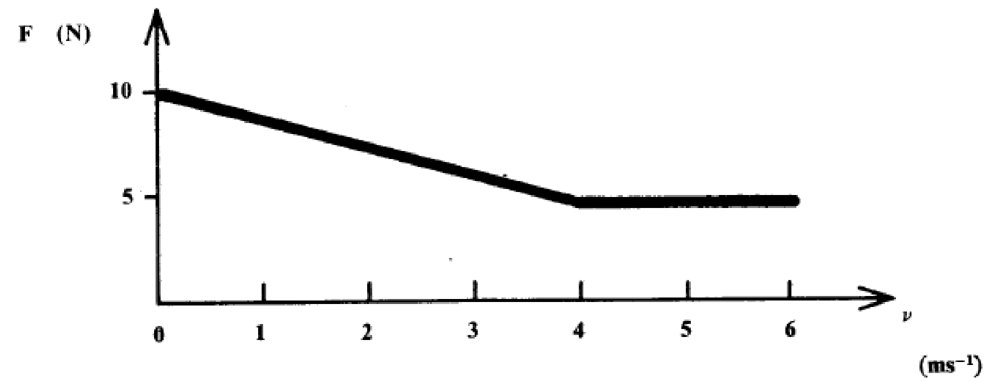
How much work has been done on the particle by the wall?

WD = ΔKE.
In this case the final speed is the same as the initial speed.
∴ ΔV = 0
∴ ΔKE = 0
∴ WD = 0 J (ANS)

A block of mass 2.0 kg can slide on a horizontal table (shown below) and is subjected to two forces:



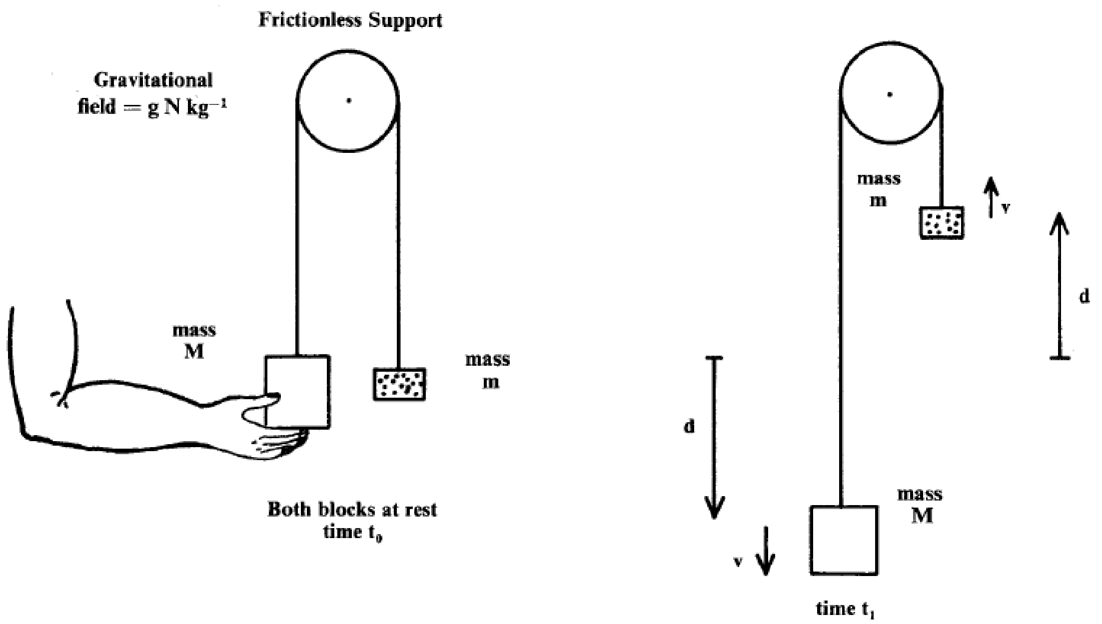
F the driving force, which varies with velocity as shown below, and
f, the friction force, which is a constant 5 N.



1982 Question 17, 1 mark 69%

At what rate is heat being generated due to the friction force when the speed is 4 m s^{-1}?

The rate at which heat is generated at is the power.
Use $P = F v$
$\therefore P = 5 \times 4$ *(from the graph)*
$\therefore$ ***20 W (ANS)***



1982 Question 18, 1 mark 71%

At time t_0, what is the force of the person's hand on block M?

A. zero

B. Mg

C. Mg + mg

D. Mg - mg

The net force acting on mass M = 0. The hand is pushing up, the weight of mass, M, is acting down and the weight of mass, m, is acting upwards. Ignoring the force from the hand, the force acting on mass, M, is Mg – mg. The force from the hand has this magnitude, to balance the mass, M. $\therefore$ ***D (ANS)***

1982 Question 19, 1 mark 70%

What is the magnitude of the change in potential energy of the system, between times t_0 and t_1?

A. Mgd

B. mgd

C. $\frac{M+m}{2}gd$

D. (M – m)gd

E. (M + m)gd

F. zero

Mass, M, has lost Mgd joules of potential energy, whilst mass, m, has gained mgd.
Therefore the difference is

Mgd – mgd

$\therefore$ *(M – m)gd*

$\therefore$ ***D (ANS)***

1982 Question 20, 1 mark 30%

What is the speed v of the larger block (M) at time t_1?

A. $\sqrt{2gd}$

B. $\sqrt{\frac{2(M-m)gd}{M+m}}$

C. $\sqrt{\frac{2(M+m)gd}{M}}$

D. $\sqrt{\frac{(M+m)gd}{M}}$

E. $\sqrt{\frac{2(M-m)gd}{M}}$

The total energy of this system is conserved. Therefore the change in PE must is equal to the gain of KE. Initially the KE was zero, therefore the change in KE is now the same as the actual KE
For the system (of both masses) the KE is
(M – m)gd (from the previous question).

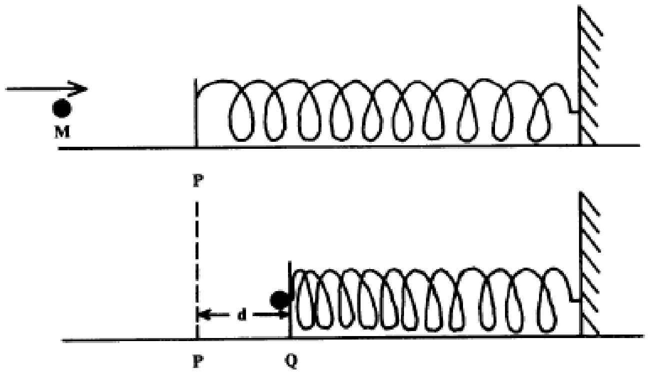
$\therefore KE = (M - m)gd$

$\therefore \frac{1}{2}(M + m)v^2 = (M - m)gd$

$\therefore v^2 = \frac{2(M-m)}{(M+m)}gd$

$\therefore v = \sqrt{\frac{2(M-m)}{(M+m)}gd}$

$\therefore$ ***B (ANS)***

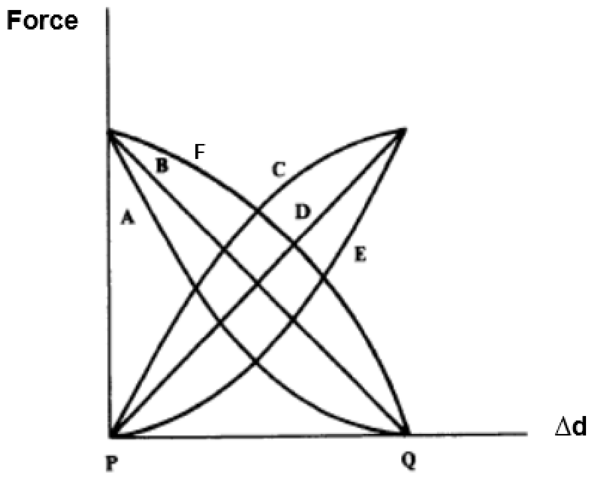


A moving mass M, strikes and sticks to the end of a light spring of spring constant *k*, which is lying on a smooth surface as shown above. As a result of this impact the spring is compressed by an amount *d* from *P* before it comes momentarily to rest at *Q*.

1982 Question 29, 1 mark 52%

Which of the graphs (A – F) below best shows the variations with distance, of the force exerted on the spring by the mass *M*?

Using $F = k\Delta x$
The graph needs to be a straight line.
$\therefore$ ***D (ANS)***



Between the two situations shown in the first diagram, the potential energy stored in the spring changed by ΔV.

1982 Question 30, 1 mark 54%

Write an expression for ΔV in terms of the symbols defined above.

The energy stored in the spring is given by
$E = \frac{1}{2} k\Delta x^2$.
In this example this is written as
PE = $\frac{1}{2} kd^2$ (ANS)

1982 Question 31, 1 mark 81%

Which of the expressions below is correct for the velocity of the mass when it first contacted the end of the spring?

A. $\frac{1}{2}kd^2$

B. kd

C. $\sqrt{\frac{k}{m}}d$

D $\frac{1}{2\pi}\sqrt{\frac{k}{m}}$

When the mass first contacts the spring, the mass has KE and the stored energy in the spring = 0.
When the mass comes to rest at Q, its
KE = 0, and the spring has stored energy, given by $\frac{1}{2}k\Delta x^2$.

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

$\therefore mv^2 = kd^2$

$\therefore v^2 = \frac{kd^2}{m}$

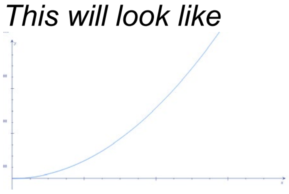
$\therefore v = \sqrt{\frac{k}{m}}d$

$\therefore$ ***C (ANS)***

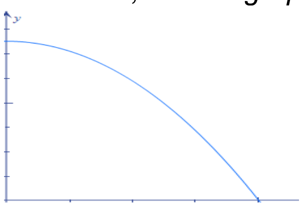
1982 Question 32, 1 mark

Which of the graphs (**A – E**) best shows the variation of the kinetic energy of the mass as it moves from *P* to *Q?*

The KE will go from a maximum to a minimum (in this case, 0).
It will not be linear.
The sum of $KE_{mass} + PE_{spring}$ = constant.
The energy stored in the spring is given by
$E = \frac{1}{2}k\Delta x^2$.
This will look like

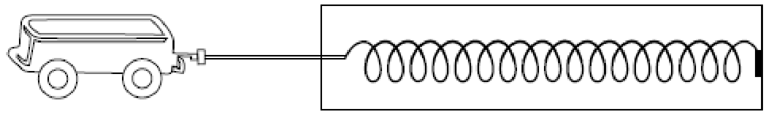


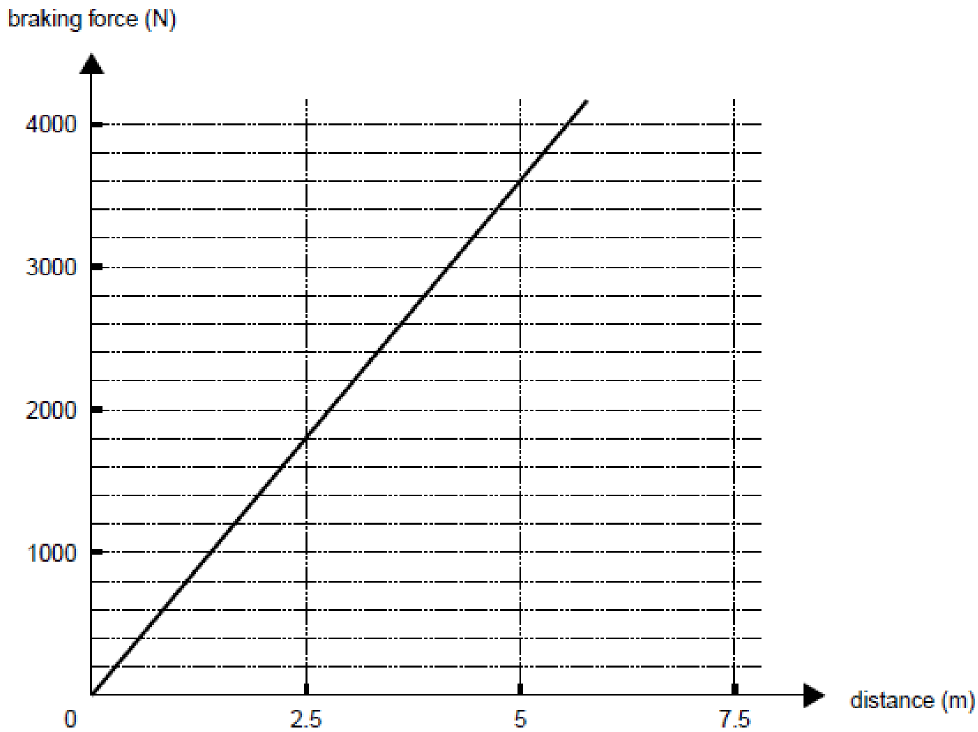
Therefore, the KE graph must look like



$\therefore$ **F (ANS)**

At the end of the roller-coaster ride the cart is brought to rest by compressing a spring as shown in the figure below. The force-compression graph for the spring is shown below.





1998 Question 17, 2 marks 30%

If the 500 kg cart is travelling at 6.0 m s^{-1} just prior to coming in contact with the spring, calculate the stopping distance of the cart.

When the cart comes to rest, the spring will be compressed to its maximum, and all the KE of the cart will be stored in the spring.

The KE = $\frac{1}{2} \times 500 \times 6^2 = 9\,000$ *J.*

The energy stored in the spring is given by

$$EPE = \frac{1}{2} k\Delta x^2.$$

Where k is the gradient of the graph.

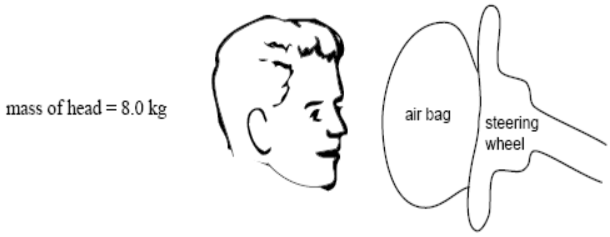
$$\therefore k = \frac{3600}{5} = 720 \text{ N m}^{-1}$$

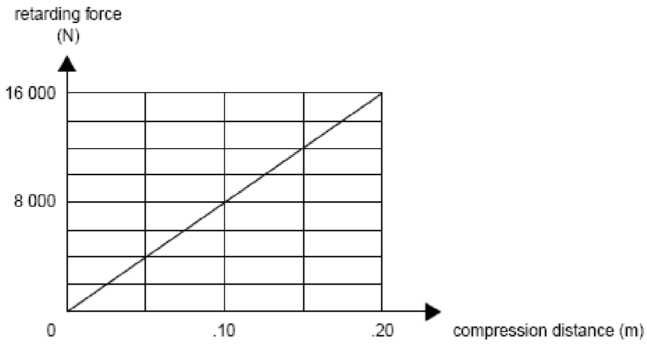
$$\therefore EPE = \frac{1}{2} \times 720 \times x^2 = 9\,000$$

$$\therefore x^2 = \frac{9000 \times 2}{720} = 25$$

$$\therefore \boldsymbol{x = 5 \text{ m (ANS)}}$$

A car, equipped with a driver's air bag, hits a large tree while travelling horizontally at 54 km h^{-1}
(15 m s^{-1}). The air bag is designed to protect the driver's head in a collision.
Model this as a collision involving the driver's head (mass 8.0 kg).





Tests show that the graph of retarding force on the driver's head versus compression distance of the air bag is as shown.

2000 Question 7, 4 marks 29%

Calculate the maximum compression distance of the air bag in this collision.

$E_k = E_c$

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

at about this point you realise that you need to know the value of k, which is the gradient of the Force Distance graph.
Therefore k is

$k = \frac{F}{x}$

$k = \frac{16000}{0.2}$

$k = 8 \times 10^4 \text{ N m}^{-1}$

Now using the kinetic energy of the head as being the work done on the air bag you get.
Use $\frac{1}{2}mv^2 = \frac{1}{2}kx^2$

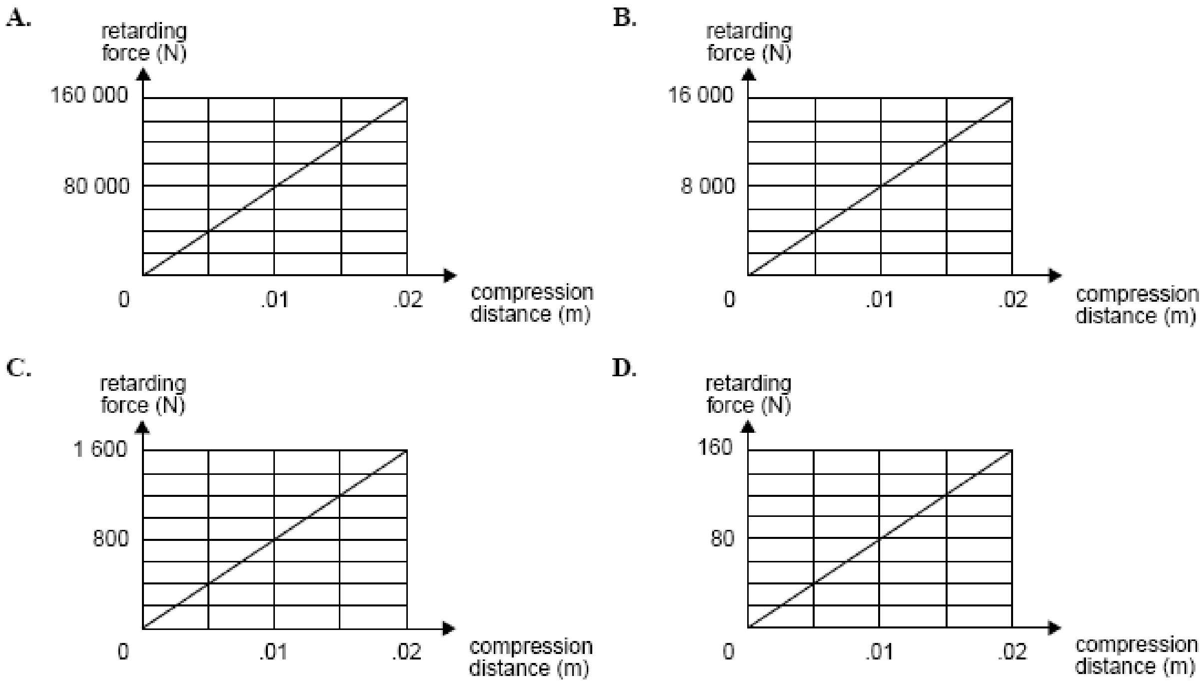
$\therefore \frac{1}{2} \times 8 \times 15^2 = \frac{1}{2} \times 8 \times 10^4 x^2$

$\therefore x = \sqrt{\frac{8 \times 15^2}{8 \times 10^4}}$

$\therefore$ x = 0.15 m (ANS)

2000 Question 8, 2 marks 72%

Which **one** of the graphs (**A–D**) best represents the retarding force versus compression distance if the collision was with the hard surface of the steering wheel rather than the air bag?



A collision with a harder surface would result in a smaller compression distance. The material must have 900 J of work done on it, and therefore the area under the graph remains constant. Hence, the required graph must have a shorter compression distance and a larger force.

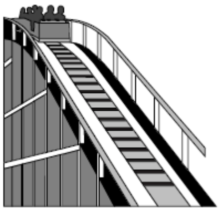
$\therefore$ ***Graph A (ANS)***

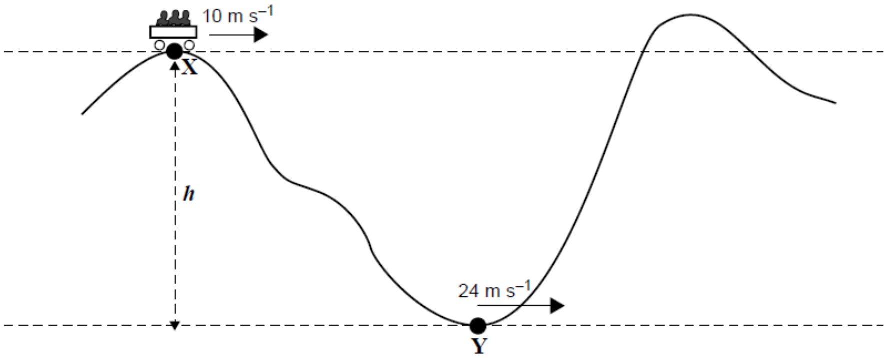
2000 Question 9, 3 marks 35%

Explain your answer to Question 8, giving specific reasons for choosing the graph that you selected as the best answer.

The specific reasons for choosing graph A needed to cover:
- *A collision with a harder surface would result in a smaller compression distance.*
- *The material must have 900J of work done on it, and therefore the area under the graph remains constant.*
- *Hence, the required graph must have a shorter compression distance and a larger force.*

Jo is riding on a roller-coaster at a fun fair.
Part of the structure is shown below.





When Jo is at point **X** her velocity is 10 m s^{-1} in a horizontal direction, and at point **Y** it is 24 m s^{-1} in a horizontal direction. At **Y** the track has a radius of curvature of 12 m.

2000 Question 14, 3 marks 45%

What is the height difference (***h***) between points **X** and **Y**? Assume that friction and air resistance are negligible. (g = 9.8 m s^{-2})

$E_{top} = \frac{1}{2}mv^2 + mgh$

$\therefore E_{top} = \frac{1}{2}m \times 10^2 + m \times 9.8 \times h$

$E_{bottom} = \frac{1}{2}mv^2$

$\therefore E_{bottom} = \frac{1}{2}m \times 24^2$

The energy is conserved; therefore the energy Jo has at the top will equal the energy Jo has at the bottom. So we can write;

$E_{bottom} = E_{top}$

$\frac{1}{2}m \times 24^2 = \frac{1}{2}m \times 10^2 + m \times 9.8 \times h$

because m is present in all part of the equation we can take it out as a common factor.

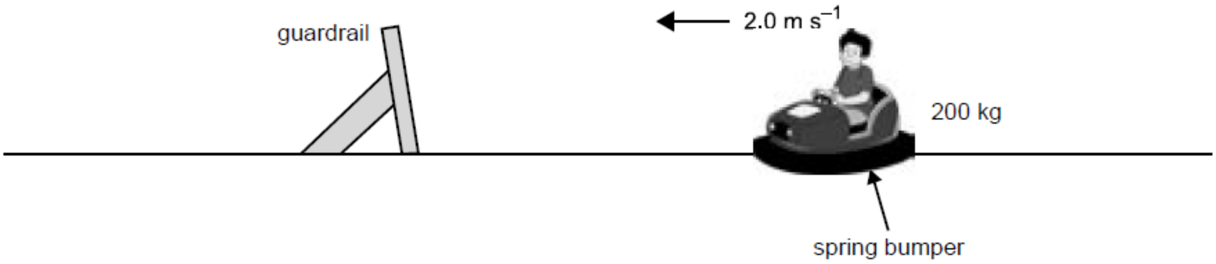
$m\left(\frac{1}{2} \times 25^2\right) = m\left(\frac{1}{2} \times 10^2 + 9.8 \times h\right)$ *the mass will now cancel on both sides.*

$\frac{1}{2} \times 24^2 = \frac{1}{2} \times 10^2 + 9.8 \times h$

$h = \dfrac{\frac{1}{2} \times 24^2 - \frac{1}{2} \times 10^2}{9.8}$

$\therefore$ ***h = 24.3 m (ANS)***

Kim is driving a dodgem car. He is travelling at 2.0 m s^{-1} when he hits an oil patch and collides head-on with the guardrail. The dodgem car (shown below) has a spring-loaded bumper. After the collision the dodgem car rebounds directly backwards along the same line at a speed of 2.0 m s^{-1}. The spring constant of the bumper is 3.2×10^5 N m^{-1} and the mass of Kim and the dodgem car is 200 kg.



2003 Question 6, 3 marks 34%

Calculate the maximum compression of the bumper spring during this head-on collision.

The KE of the dodgem car is stored in the spring at maximum compression, because at this point the car is stationary and so has 0 KE.

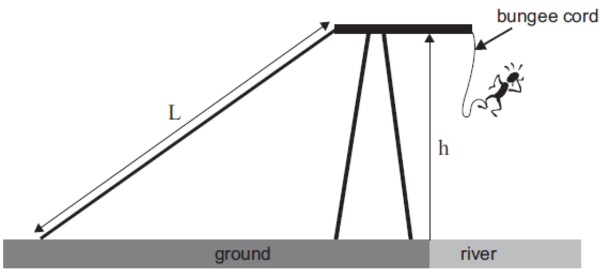
$\therefore \frac{1}{2} mv^2 = \frac{1}{2} kx^2$

$\therefore 0.5 \times 200 \times 2^2 = 0.5 \times 3.2 \times 10^5 \times x^2$

$\therefore x^2 = \frac{400}{1.6 \times 10^5}$

$\therefore$ ***x = 0.05 m (ANS)***

A student, Sam, of mass 70 kg, is bungee jumping from a platform at the top of a tower. He reaches the top of the tower by being towed up a slide of length L. The friction between Sam and the slide provides a constant force of 300 N that opposes the motion. The **total work** done in dragging Sam up the slide to the top of the tower is 22 720 J. At the top of the tower Sam's **potential energy** was greater by 13 720 J than it was on the ground.



2006 Question 12, 3 marks 37%

Show that the length of the slide, L, is 30 m.

Work done = F × d

$E_{total} = F \times d + mgh$

$\therefore 22\,720 = F \times d + 13\,720$

$\therefore F \times d = 9\,000$

$\therefore 300 \times d = 9\,000$

$\therefore$ ***d = 30 m (ANS)***

2006 Question 13, 2 marks 37%

What is the height, h, of the tower?

Gain in PE = mgh

$\therefore 13720 = 70 \times 10 \times h$

$\therefore h = 19.6$ m

$\therefore$ ***h = 20 m (ANS)***

The natural length of the bungee cord is 10 m.
Sam stops falling and first comes to rest momentarily when the length of the bungee cord is 18 m.

2006 Question 14, 3 marks 37%

What is the spring constant of the bungee cord?

PE_{LOST} = *Energy stored in spring*

$\therefore mgh = \frac{1}{2}kx^2$

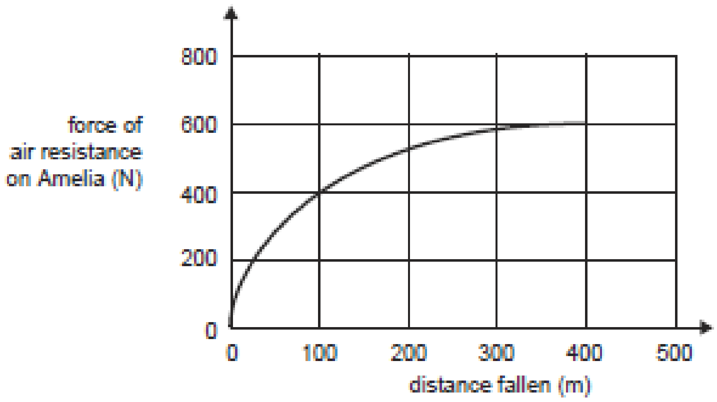
$\therefore 70 \times 10 \times 18 = \frac{1}{2} \times k \times (18 - 10)^2$

(note the extension of the cord – (18 – 10))

$\therefore k = \frac{70 \times 10 \times 18 \times 2}{8^2}$

$\therefore$ ***k = 394 N m^{-1} (ANS)***

Amelia, who has a mass of 60 kg including equipment, is skydiving. The air resistance on her as a function of the distance fallen is shown below. After falling a distance of 400 m, she has reached terminal velocity, and continues to fall at a constant speed until she opens her parachute.



2007 Question 8, 2 marks 60%

Estimate the work done by the air-resistance force on Amelia while she was falling 500 m from the plane.

Work done is always the area under the force distance graph. The best way to do this is to estimate the number of squares under the graph.
Each square has a value of 2×10^4 J.

You need to read the question very carefully because it refers to the first 500m NOT the first 400m.
Starting from the left
0.8 + 0.4 + 1 + 1 + 0.4 + 1 + 1 + 0.8 + 1 + 1 + 0.9 + 3 = 12.3 squares.
∴ Work done = 24.6 × 10^4 J
= 2.5 × 10^5 J (ANS)

In a laboratory class at school, Lee is given a spring with a stiffness of 20 N m^{-1} and unstretched length of 0.40 m. He hangs it vertically, and attaches a mass to it, so that the new length of the spring is
0.60 m.

2007 Question 9, 3 marks 43%

Assuming the spring has no mass, what was the value of the mass he attached?

The extension (change in length) is
0.6 – 0.4 = 0.2 m
$F = k\Delta x$
∴ $mg = k\Delta x$
On substitution, m × 10 = 20 × 0.2
∴ m = 0.4 kg (ANS)

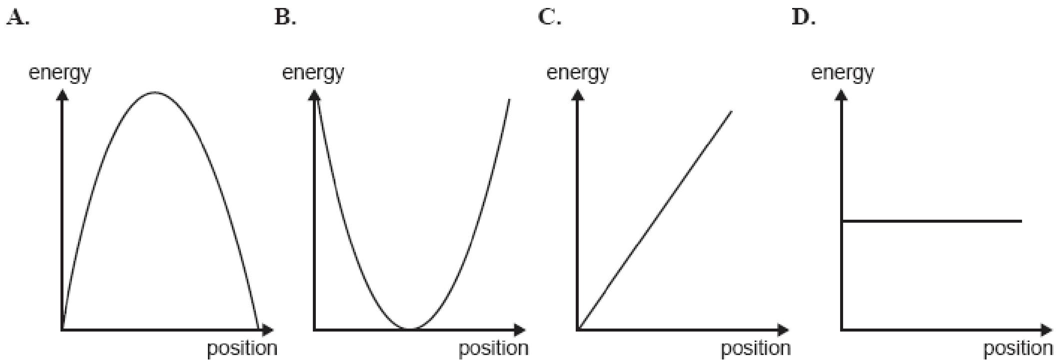
Lee pulls the mass down a further distance of 0.10 m.
2007 Question 10, 3 marks 43%

By how much has the potential energy stored in the spring changed?

WD = area under the graph. It is also given by
$\frac{1}{2}kx_f^2 \quad \frac{1}{2}kx_i^2 \quad \frac{1}{2}\times 20\times 0.3^2 \quad \frac{1}{2}\times 20\times 0.2^2$
= 0.5 J (ANS)

He now releases the mass, so that the mass-spring system oscillates. Ignore air resistance.
2007 Question 11, 2 marks 38%

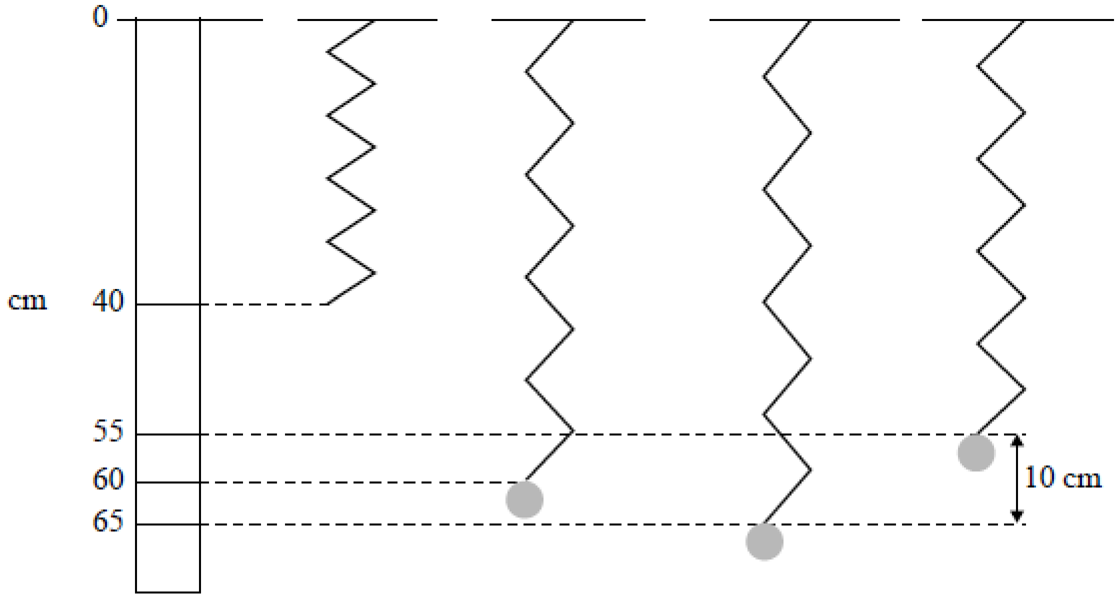
Which one of the curves (**A – D**) below could best represent the variation of the **total energy** of the oscillating mass-spring system as a function of position?



Since we can ignore air resistance (stated in the question) the system does not lose energy.
∴ the total energy is constant.
∴ D (ANS)

Use the following information to answer Questions 12–14.

A novelty toy consists of a metal ball of mass 0.20 kg hanging from a spring of spring constant
k = 10 N m-1.
The spring is attached to the ceiling of a room as shown below. Ignore the mass of the spring.



Without the ball attached, the spring has an unstretched length of 40 cm. When the ball is attached, but not oscillating, the spring stretches to 60 cm.

2008 Question 12, 2 marks 50%

How much energy is stored in the spring when the ball is hanging stationary on it?
You must show your working.

The energy stored in the spring is $\frac{1}{2}kx^2$

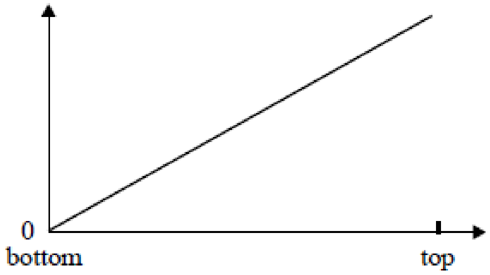
= 0.5 × 10 × (0.2)^2 *(use metres)*

= 0.2 J (ANS)

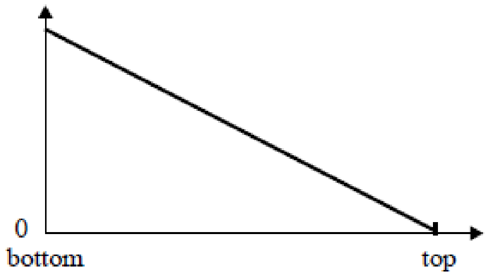
The ball is now pulled down a further 5 cm and released so that it oscillates vertically over a range of approximately 10 cm.
Gravitational potential energy is measured from the level at which the ball is released. Ignore air resistance.

Use Graphs A–E in answering Questions 13 and 14.

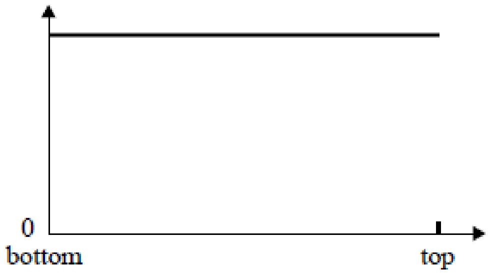
A.



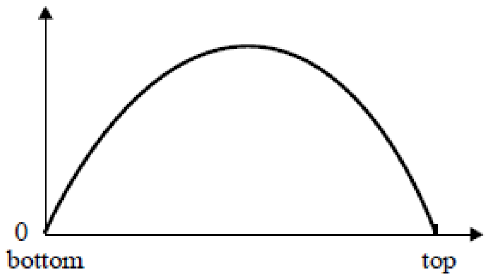
B.



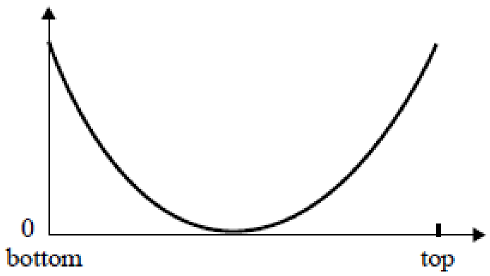
C.



D.



E.



2008 Question 13, 2 marks 38%

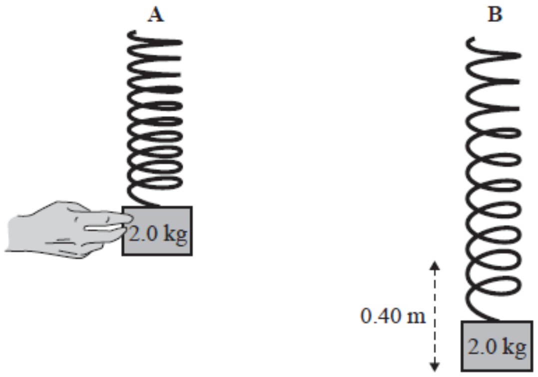
Which of the graphs best represents the shape of the graph of **kinetic** energy of the system as a function of height?

The ball will be stationary (momentarily) at the top and the bottom of the oscillation. Therefore the KE will be zero at these points. The KE will be a maximum at the midpoint.
∴ D (ANS)

2008 Question 14, 2 marks 50%

Which of the graphs best represents the **gravitational potential** energy of the system as a function of height?

The gravitational potential energy is measured from the point of release.
∴ at the bottom, PE = 0.
∴ A (ANS)



The first figure shows an ideal spring with a 2.0 kg mass attached. The spring-mass system is held so that the spring is not extended. The mass is **gently** lowered and the spring stretches until, the spring-mass system is at rest. The spring has extended by 0.40 m.

2010 Question 13, 2 marks 54%

What is the value of the spring constant, *k*, of the spring?

When the spring has extended 0.40 m, the mass is in equilibrium.

$\therefore mg = k\Delta x.$

You must ALWAYS use Δx, to remind yourself that it is the extension of the spring, not the length of the spring that is used in calculations.

$\therefore 2.0 \times 10 = k \times 0.40$

$\therefore$ ***k = 50 N m^{-1} (ANS)***

2010 Question 14, 2 marks 36%

What is the difference in the magnitude of the total energy of the **spring-mass system** between the two figures? Show your working.

The initial energy stored in the spring is zero.

The initial GPE of the 2 kg mass can be said to be mgh = 2.0 × 10 × 0.

= 8 J

The final energy stored in the spring is given by $E = \frac{1}{2}kx^2$

Use mg = fx to give k

$$\therefore k = \frac{2.0 \times 10}{0.4}$$

$= 50$

$\therefore E = 0.5 \times 50 \times 0.4^2$

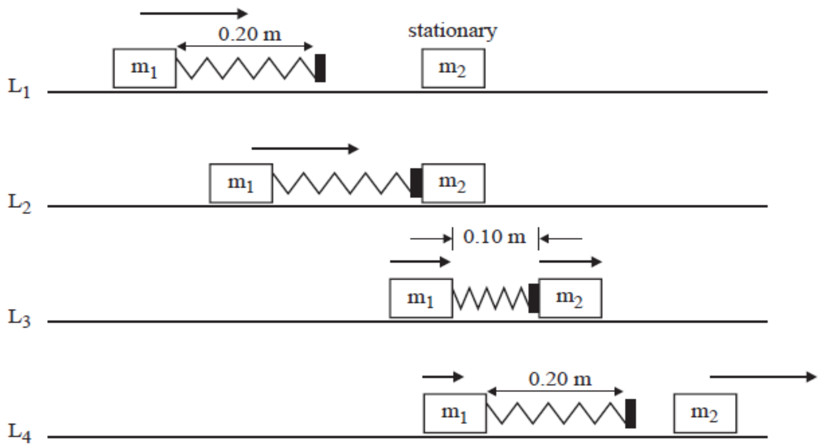
$\therefore E = 4\ J$

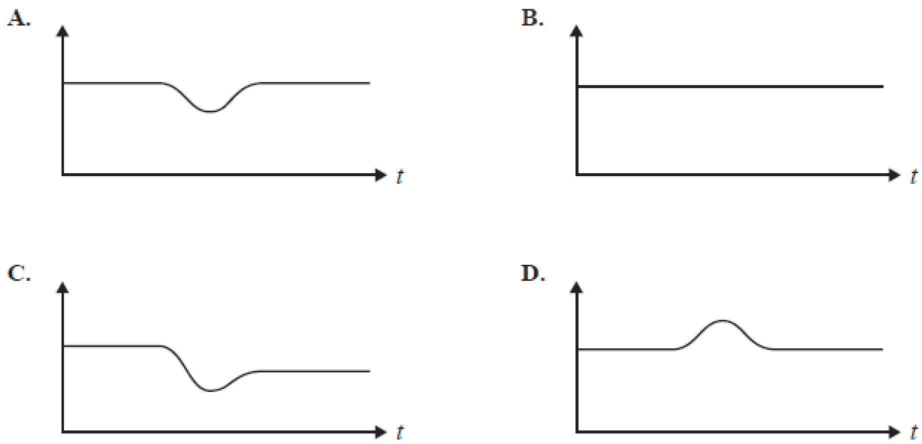
Therefore the spring gained 4 J whilst the mass lost 8 J of GPE.

*The difference is **4.0 J (ANS)***

Physics students are conducting a collision experiment using two trolleys, m_1 of mass 0.40 kg and m_2 of mass 0.20 kg.

- Trolley m_1 has a light spring attached to it.
- When uncompressed, this spring has a length 0.20 m.
- Trolley m_1 is initially moving to the right. Trolley m_2 is stationary.
- The trolleys collide, compressing the spring to a length of 0.10 m.
- The trolleys then move apart again, and the spring reverts to its original length (0.20 m), and both trolleys move off to the right.
- The collision is elastic.
- The trolleys do not experience any frictional forces.





2010 Question 15, 2 marks 44%

Which graph best shows how the total kinetic energy of the system varies with time before, during and after the collision? Explain your answer.

Since the collision is elastic, the final KE will be the same as the initial KE. During the collision energy is stored in the spring, so the KE will decrease.

∴ A (ANS)