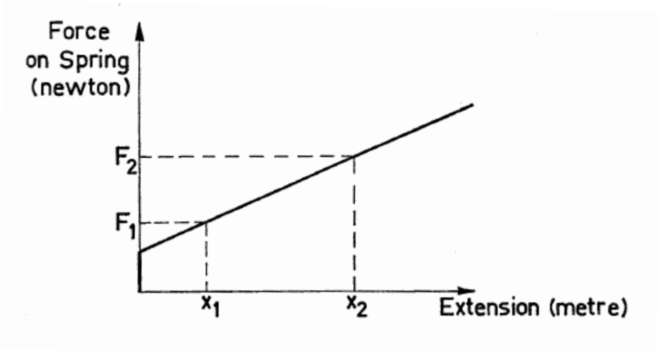
The force-extension graph of a spring is show below.



1970 Question 31, 1 mark

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

1970 Question 32, 1 mark

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

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

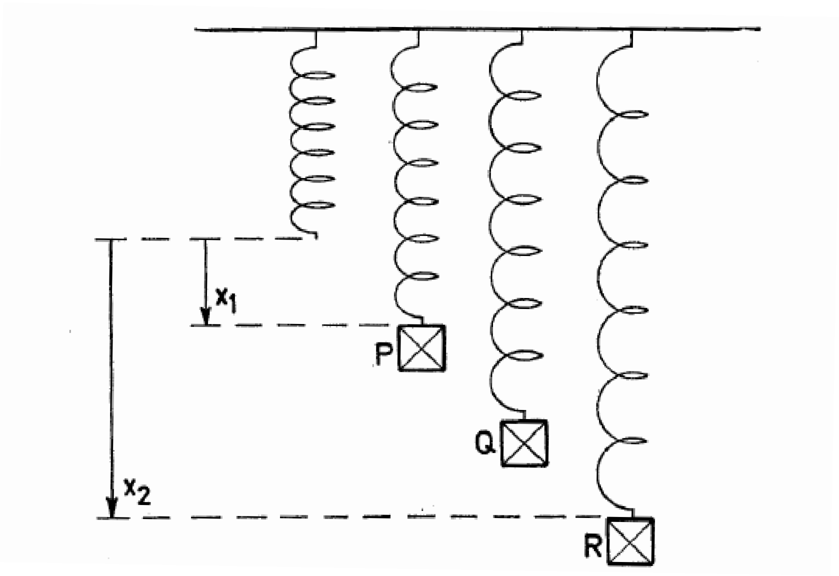
B. $(F_2 - F_1)(x_2 - x_1)$

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

D. $F_2x_2 = F_1x_1$

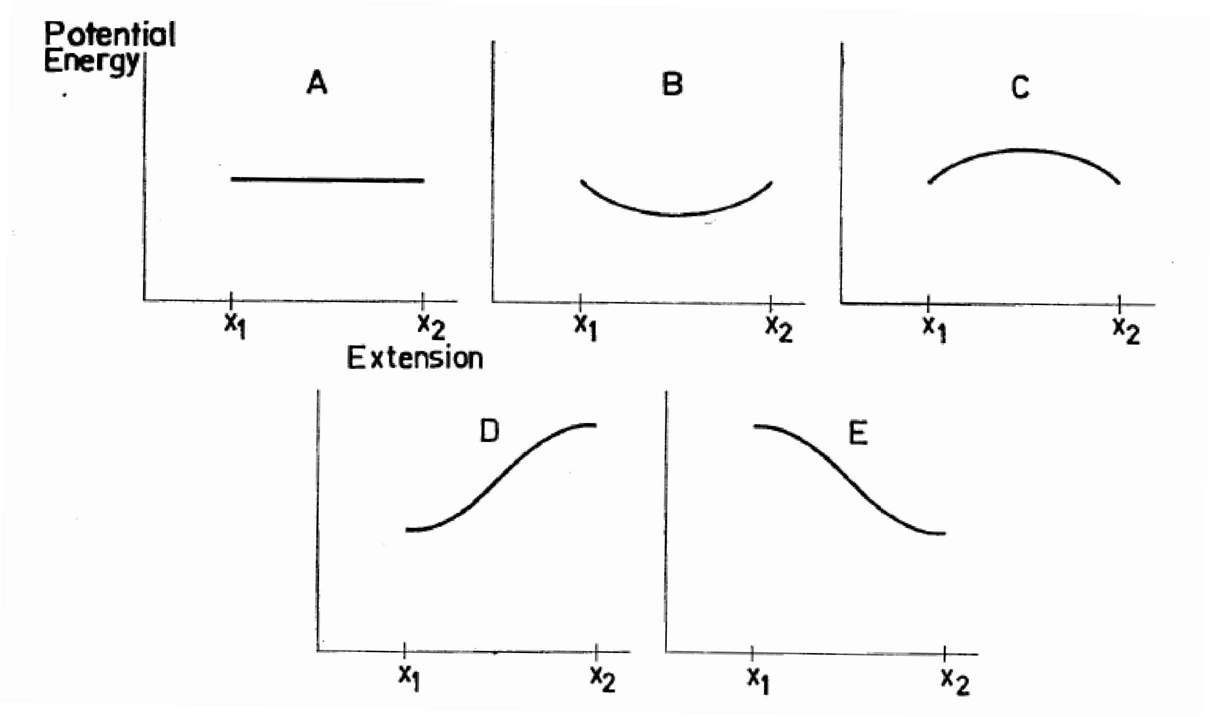
E. $\frac{1}{2}(F_2 + F_1)(x_2 - x_1)$

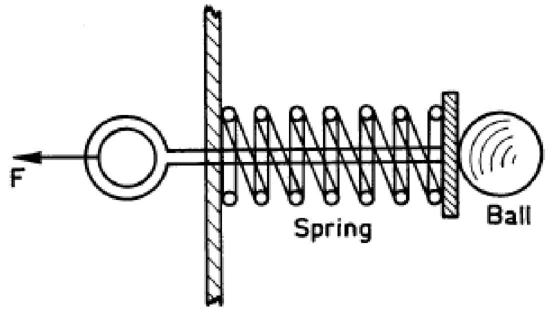
A mass of m kg is now hung from this spring. The mass is held at, P (at extension x_1) and then released; it passes through a mean position Q, to R (at extension x_2) and then returns. The motion is depicted below.

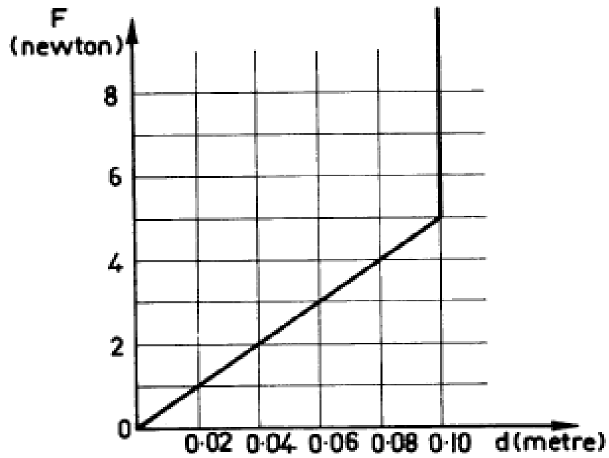


1970 Question 33, 1 mark

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?







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

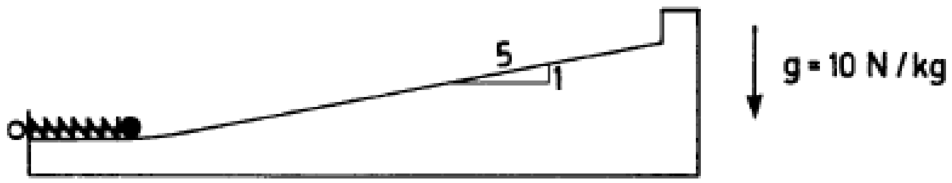
What is the spring constant of the spring before it is fully compressed?

1973 Question 36, 1 mark

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

1973 Question 37, 1 mark

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



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

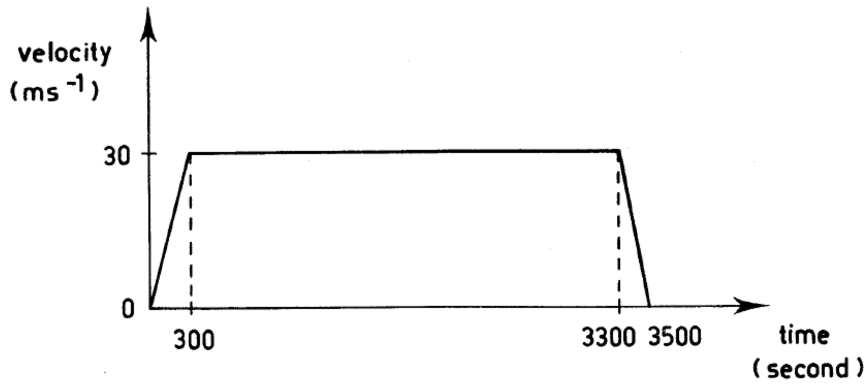
1973 Question 38, 1 mark

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?

1973 Question 39, 1 mark

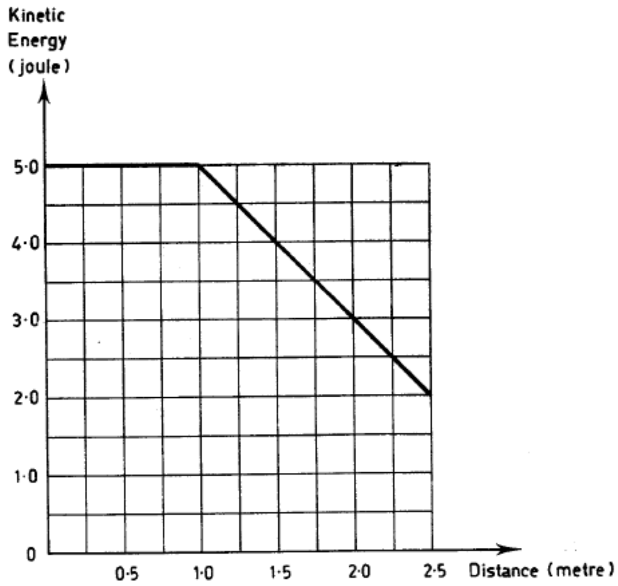
The table has a slope of 1 in 5. How far along the surface of the table could the ball travel? (answer in terms of *v*)

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 (not strictly on the course, but of interest)

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



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

What is the initial velocity of the puck?

1976 Question 15, 1 mark

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

1976 Question 16, 1 mark

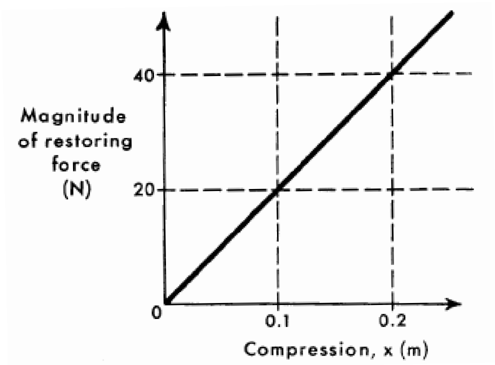
What is the magnitude of the frictional force?

1976 Question 17, 1 mark

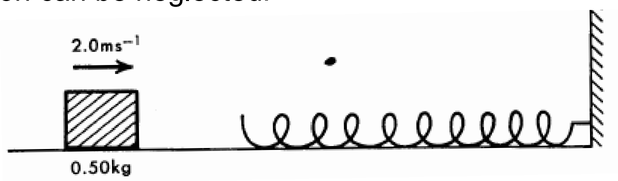
The puck reaches the edge of the table and falls to the floor 1.0 metre below the table. What is the total energy of the puck just before striking the floor?

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.



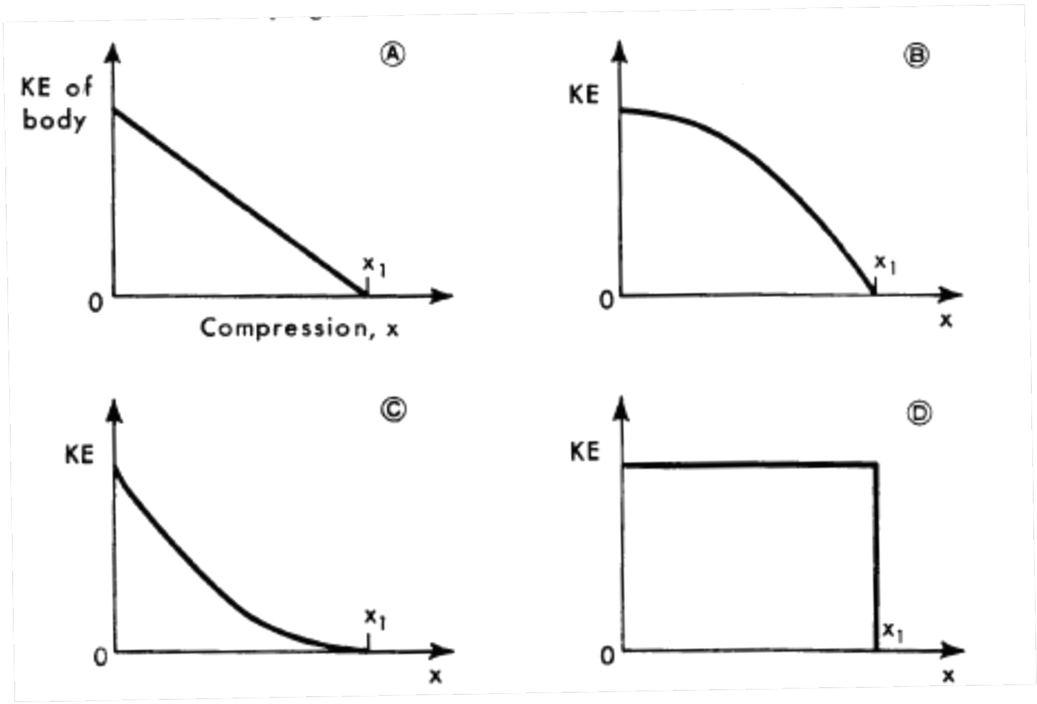
The body comes to rest instantaneously at a time t_1, when the spring is compressed by a total amount x_1, It then rebounds.

1977 Question 21, 1 mark

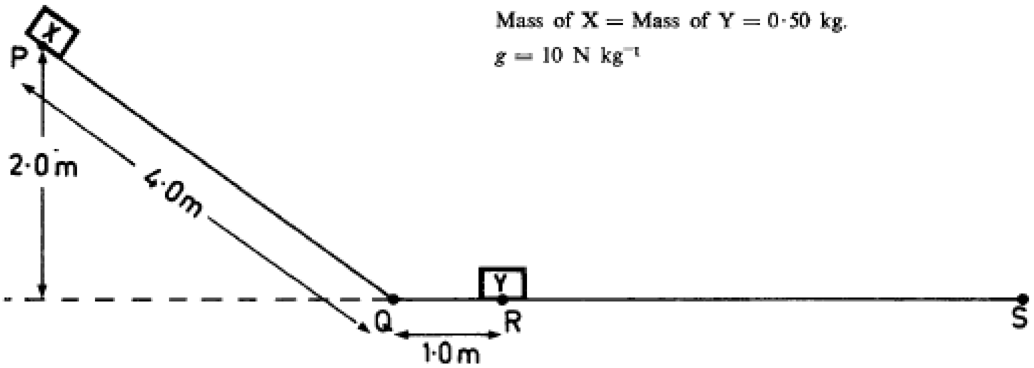
Calculate the value of x_1.

1977 Question 22, 1 mark

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



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

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?

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

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

1978 Question 29, 1 mark

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

1978 Question 30, 1 mark

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

1978 Question 31, 1 mark

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

1978 Question 32, 1 mark

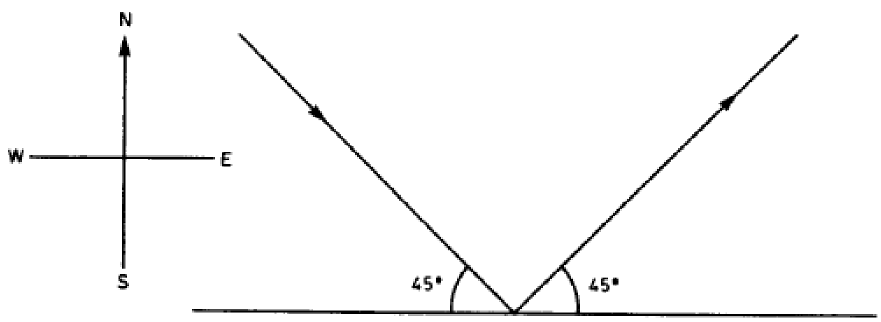
The kinetic energy of the two blocks at the end of their motions is zero, i.e. it is less than the initial potential energy of block X. Which of the following statements provides the best explanation for this?

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.

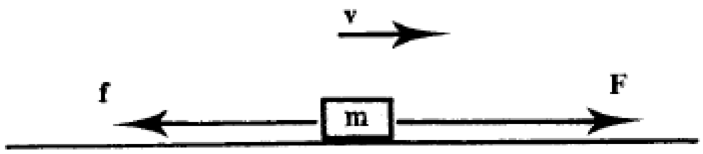


A particle of mass *m*, travelling south-east at constant speed *v*, hits a wall and then travels north-east at the same speed *v*.

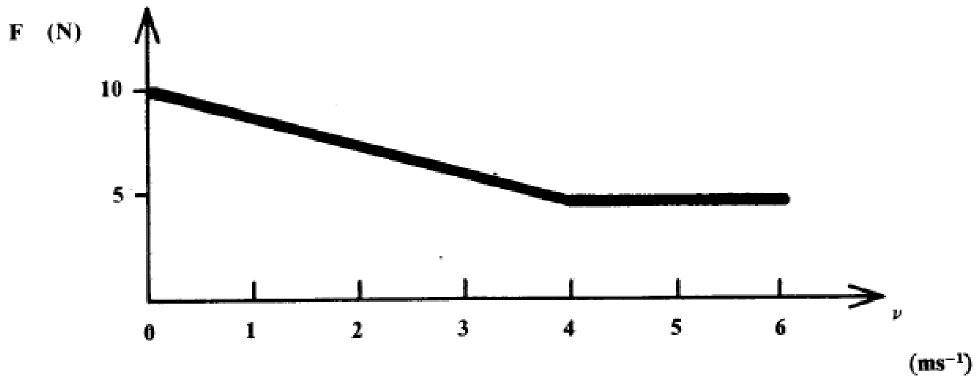
1980 Question 16, 1 mark

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

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

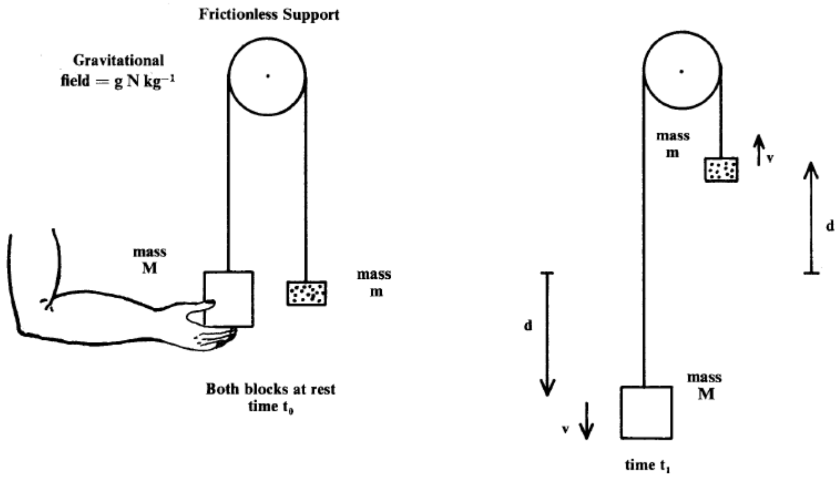


F the driving force, which varies with velocity as shown below, and
f, the friction force, which is a constant 5 N.



1982 Question 17, 1 mark

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



1982 Question 18, 1 mark

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

1982 Question 19, 1 mark

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

1982 Question 20, 1 mark

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

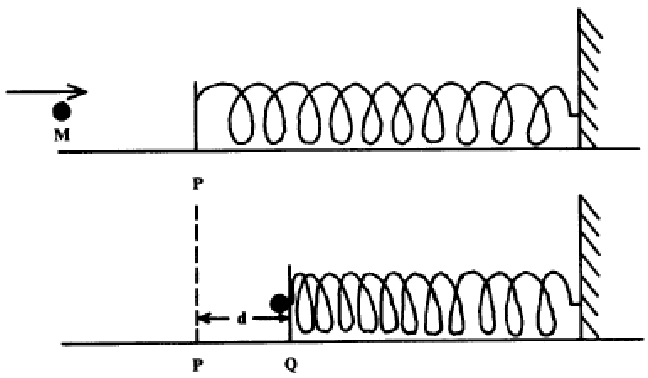
A. $\sqrt{2gd}$

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

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

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

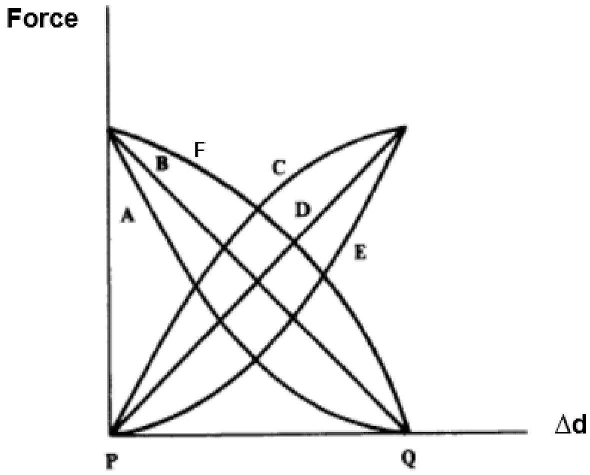
E. $\sqrt{\frac{2(M-m)gd}{M}}$



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

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



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

1982 Question 30, 1 mark

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

1982 Question 31, 1 mark

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

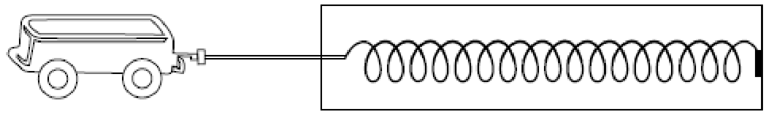
C. $\sqrt{\frac{k}{m}}d$

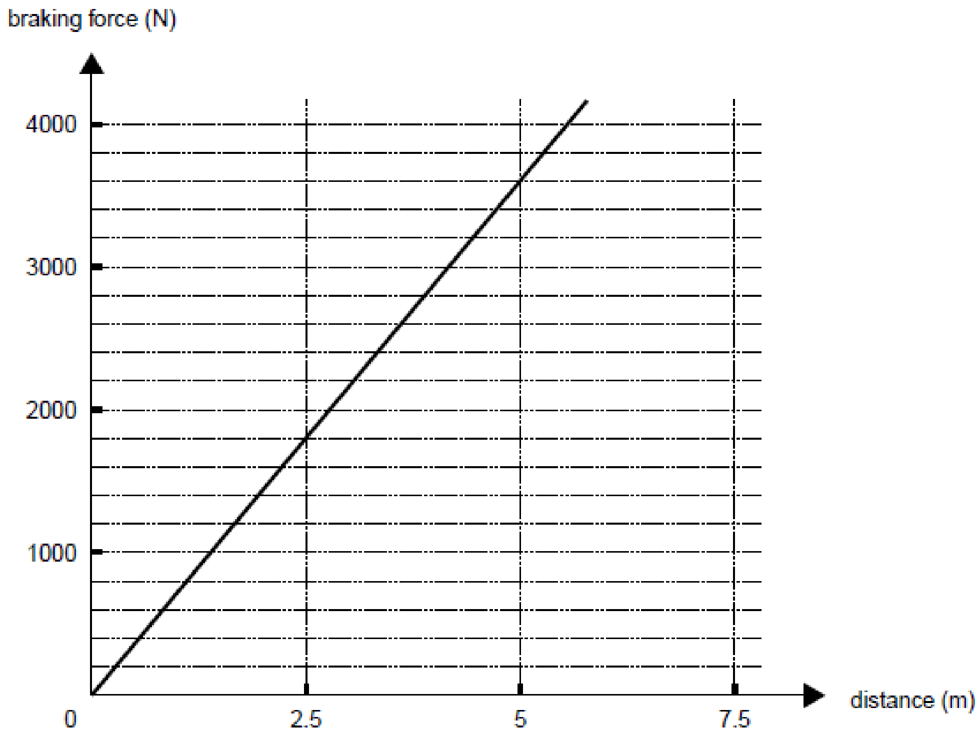
D $\frac{1}{2\pi}\sqrt{\frac{k}{m}}$

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?*

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.

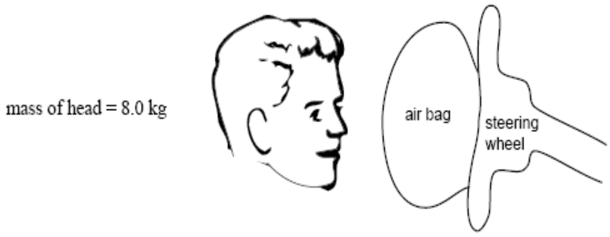


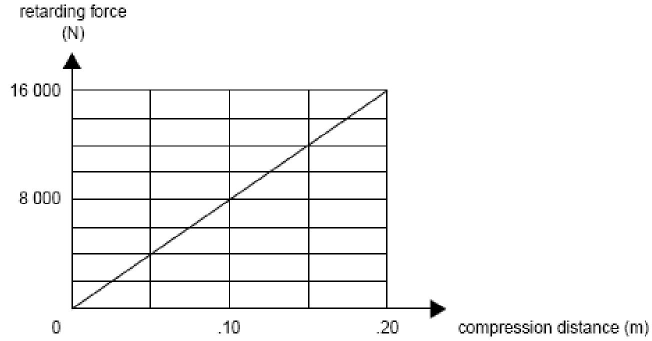


1998 Question 17, 2 marks

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.

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.

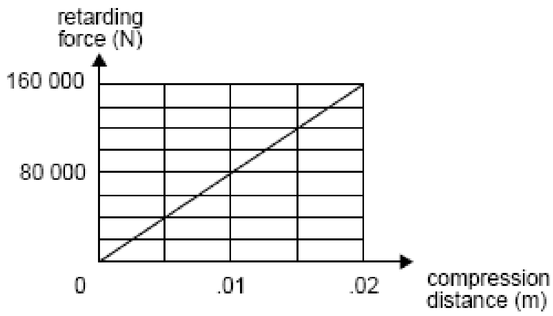
2000 Question 7, 4 marks

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

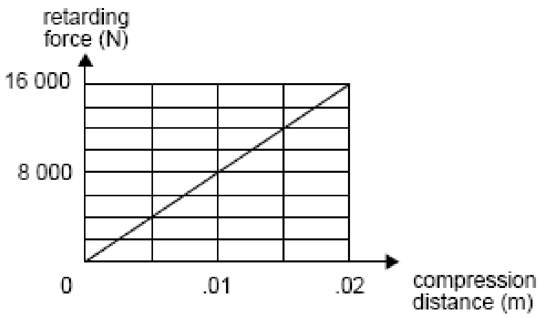
2000 Question 8, 2 marks

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?

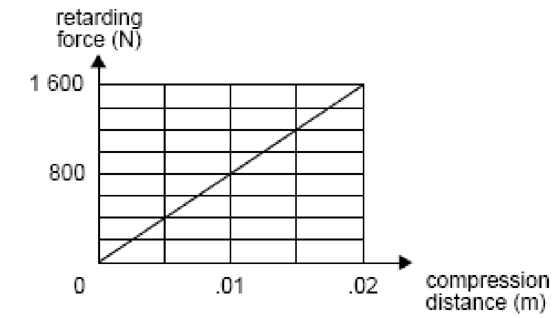
A.



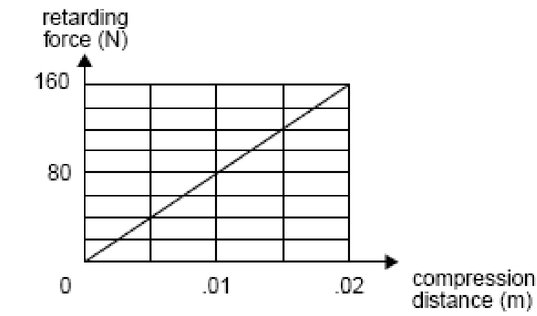
B.



C.



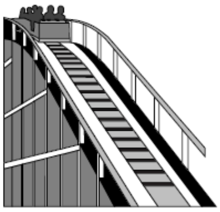
D.

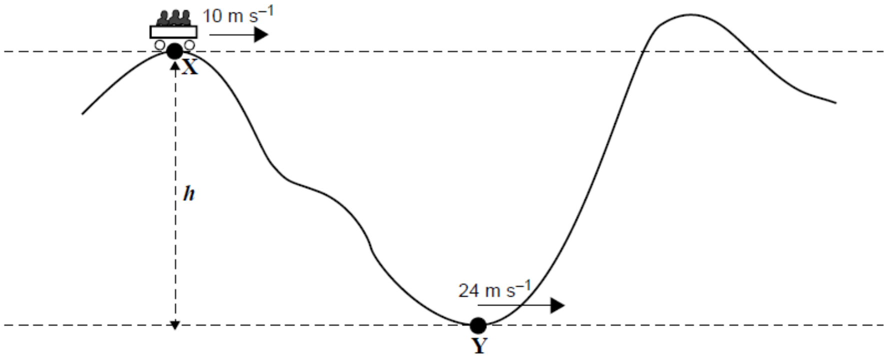


2000 Question 9, 3 marks

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

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



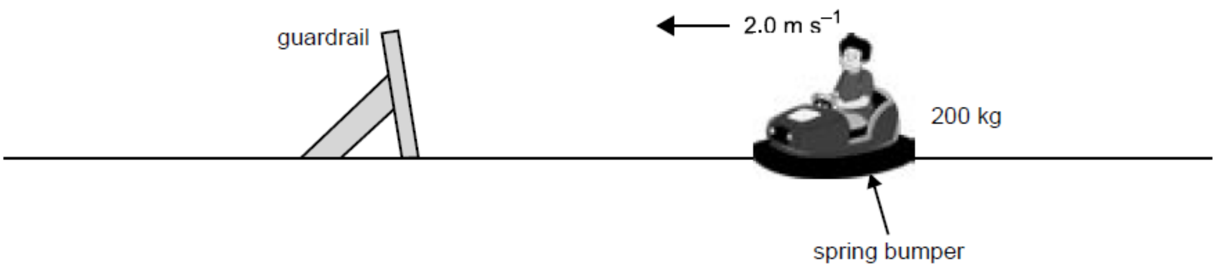


When Jo is at point **X** her velocity is 10 m s^{-1} in a horizontal direction, and at point **Y** it is 24 m s^{-1} in a horizontal direction. At **Y** the track has a radius of curvature of 12 m.

2000 Question 14, 3 marks

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})

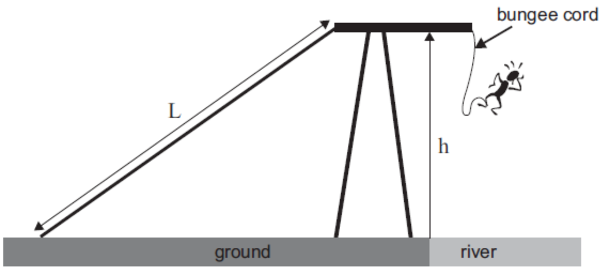
Kim is driving a dodgem car. He is travelling at 2.0 m s^{-1} when he hits an oil patch and collides head-on with the guardrail. The dodgem car (shown below) has a spring-loaded bumper. After the collision the dodgem car rebounds directly backwards along the same line at a speed of 2.0 m s^{-1}. The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

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

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

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

2006 Question 13, 2 marks

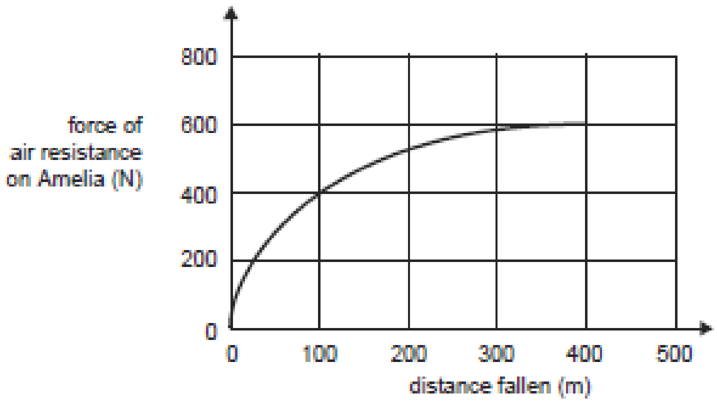
What is the height, h, of the tower?

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

What is the spring constant of the bungee cord?

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

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

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

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

Lee pulls the mass down a further distance of 0.10 m.

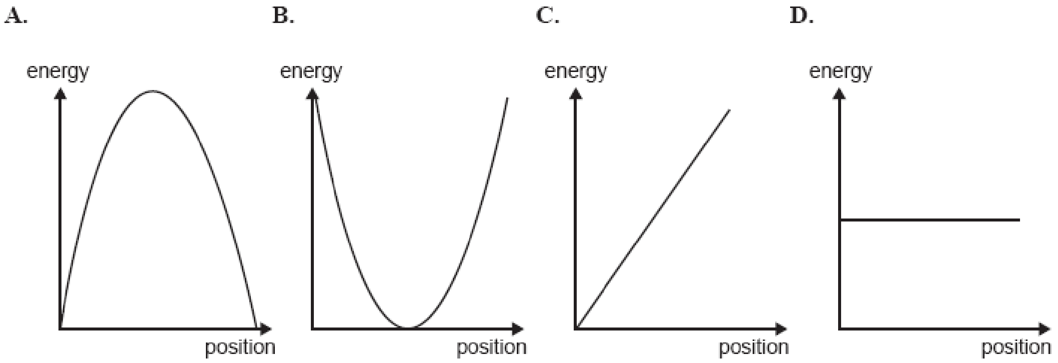
2007 Question 10, 3 marks

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

He now releases the mass, so that the mass-spring system oscillates. Ignore air resistance.

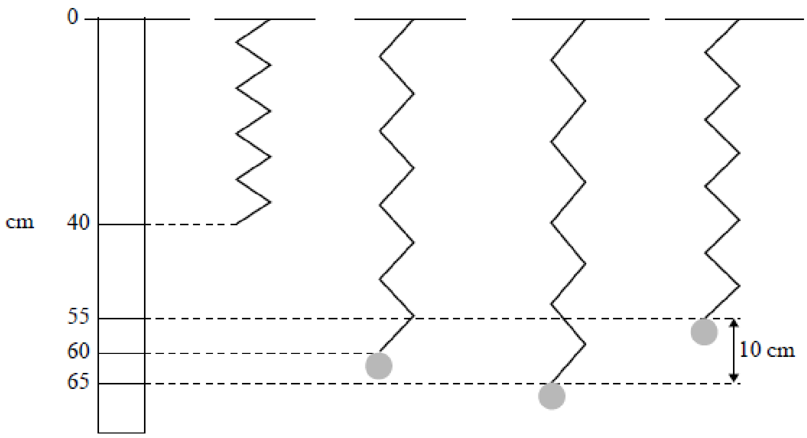
2007 Question 11, 2 marks

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?



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.

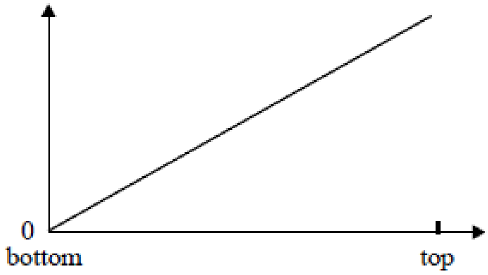
2008 Question 12, 2 marks

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

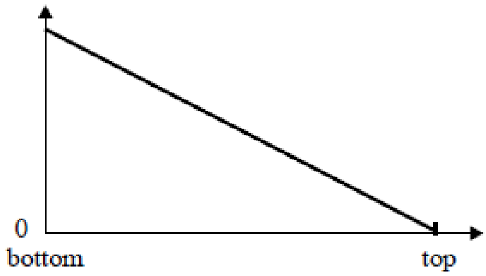
The ball is now pulled down a further 5 cm and released so that it oscillates vertically over a range of approximately 10 cm.
Gravitational potential energy is measured from the level at which the ball is released. Ignore air resistance.

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

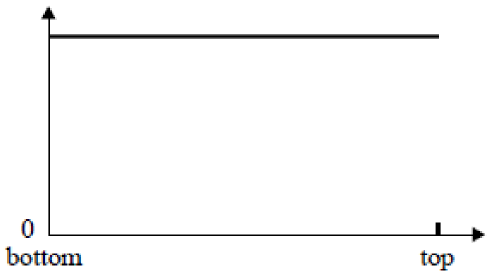
A.



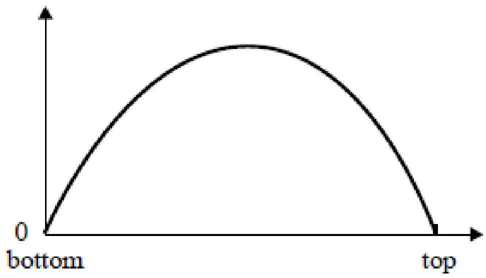
B.



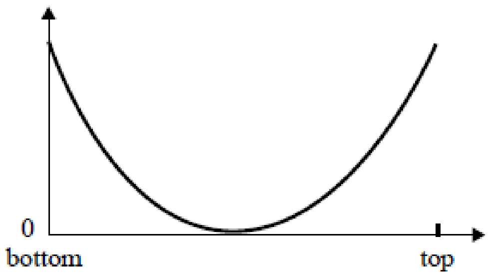
C.



D.



E.

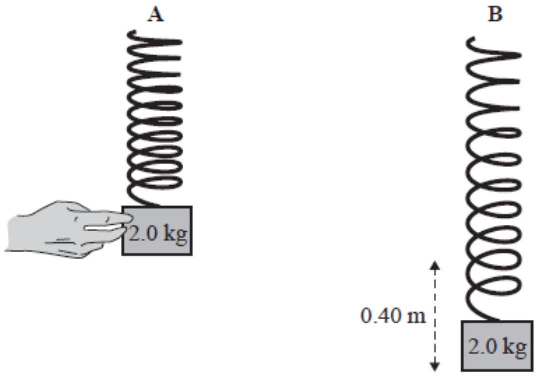


2008 Question 13, 2 marks

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

2008 Question 14, 2 marks

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



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

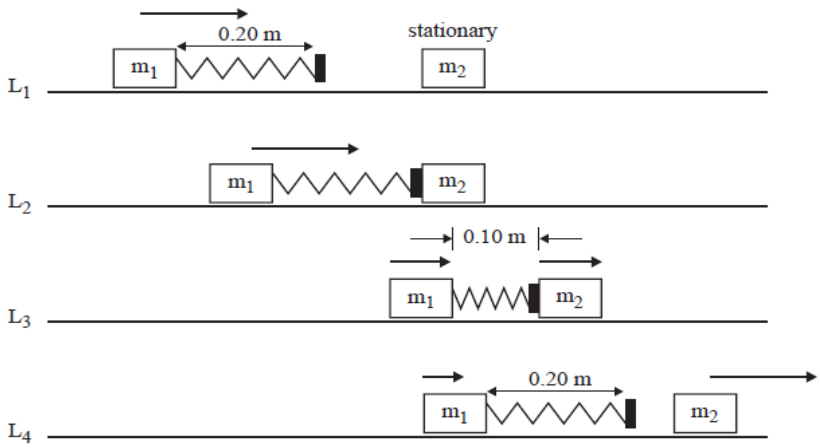
What is the value of the spring constant, *k*, of the spring?

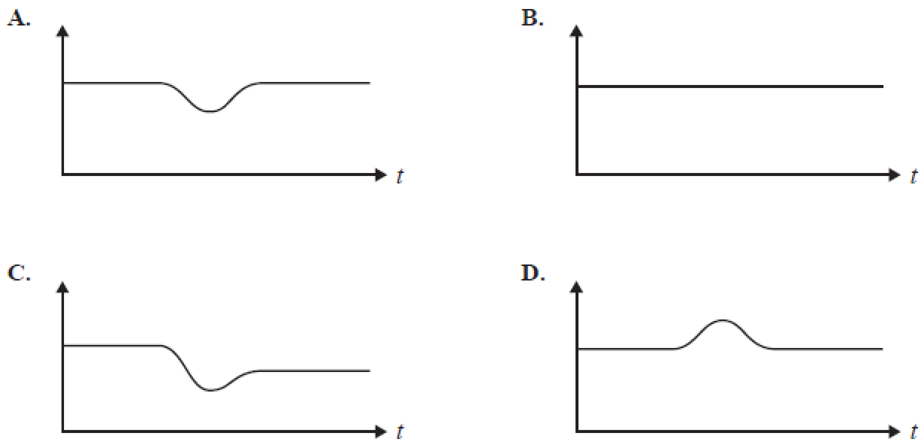
2010 Question 14, 2 marks

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

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

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