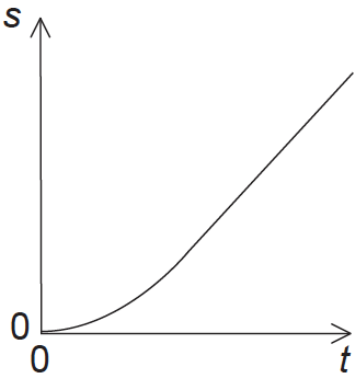
T2-1 *[201 marks]*

1. A tennis ball is dropped from the top of a tall building. Air resistance is **not** negligible. Which graph shows the variation with time *t* of the displacement *s* of the ball? *[1 mark]*

A.



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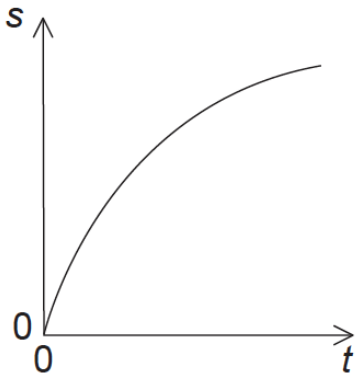
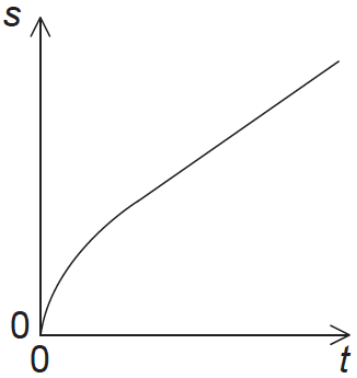


C.



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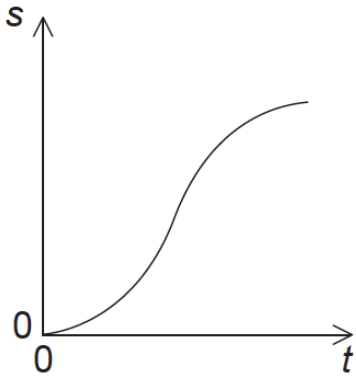


2. Which statement applies to an object in translational equilibrium? *[1 mark]*

A. The object must be stationary.

B. The object must be moving with constant acceleration.

C. The resultant force acting on the object must be zero.

D. There must be no external forces acting on the object.

3. Two identical spheres, each of mass m and speed v, travel towards each other on a frictionless surface in a vacuum. *[1 mark]*

The spheres undergo a head-on elastic collision.

Which statement correctly describes the spheres after the collision?

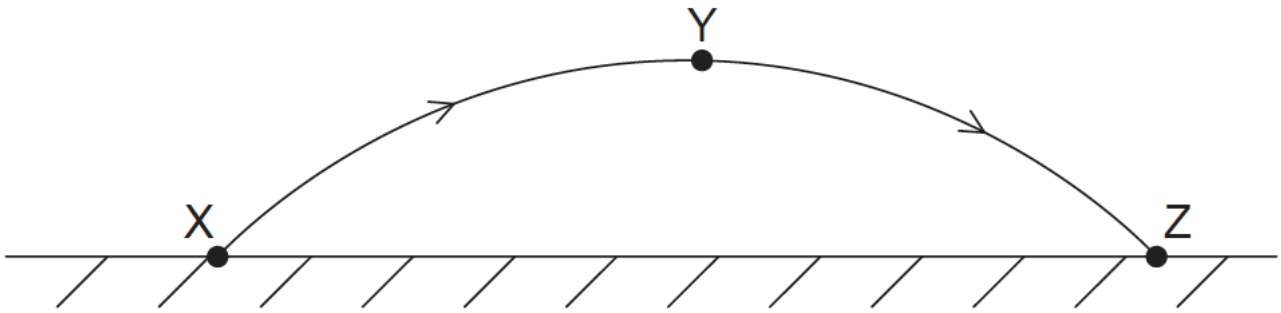
A. The total momentum of the spheres is $2mv$.

B. Each sphere has zero momentum.

C. The total kinetic energy of the spheres is mv^2.

D. Each sphere has zero kinetic energy.

4. A ball is thrown from point X and follows path XYZ. Air resistance is negligible. *[1 mark]*



Which quantity is zero when the ball is at the highest point Y of the path?

A. The horizontal component of the ball's acceleration

B. The vertical component of the ball's acceleration

C. The horizontal component of the ball's velocity

D. The kinetic energy of the ball

5. Two isolated spherical planets have the same gravitational potential at their surfaces. Which ratio must also be the same for the two planets? *[1 mark]*

A. $\frac{\text{radius}^3}{\text{mass}}$

B. $\frac{\text{radius}^2}{\text{mass}}$

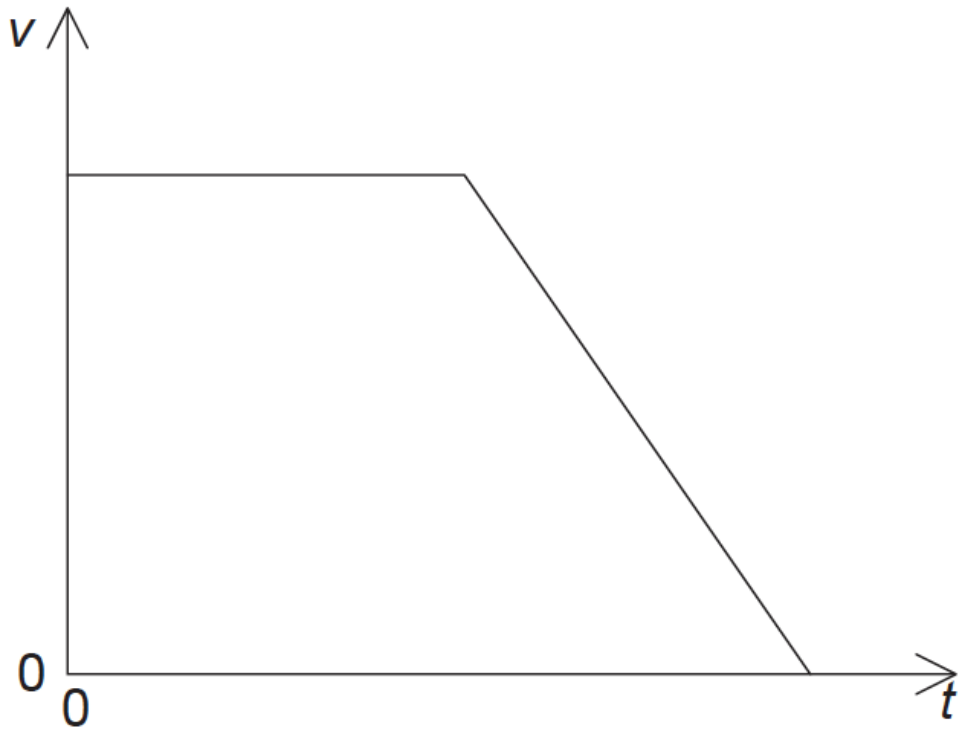
C. $\frac{\text{radius}}{\text{mass}}$

D. radius

6. A tennis ball is released from rest and falls vertically through a small distance in air. What is the change in the speed of the ball and the change in the acceleration of the ball as it falls? *[1 mark]*

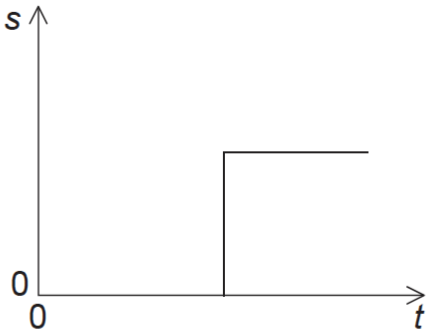
	Speed of the ball	Acceleration of the ball
A.	increases	decreases
B.	decreases	increases
C.	increases	increases
D.	decreases	decreases

7. The graph below shows the variation with time *t* of the velocity *v* of a car travelling in a straight line. *[1 mark]*

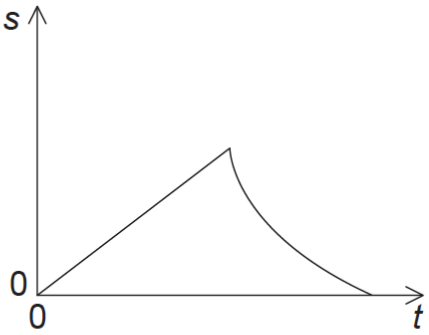


Which graph shows the variation with *t* of the displacement *s* of the car?

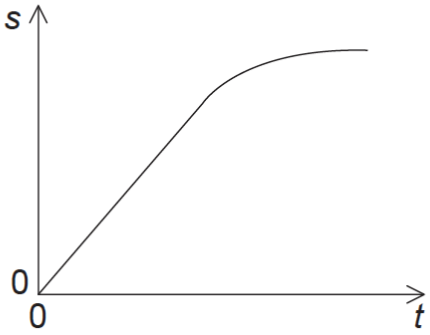
A.



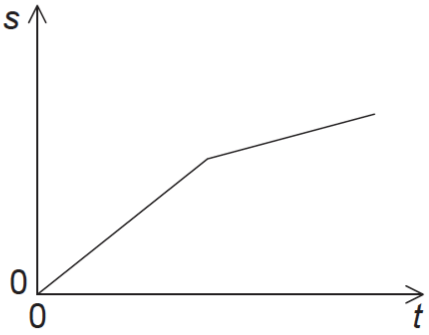
B.



C.



D.



8. Which statement applies to an object in translational equilibrium? *[1 mark]*

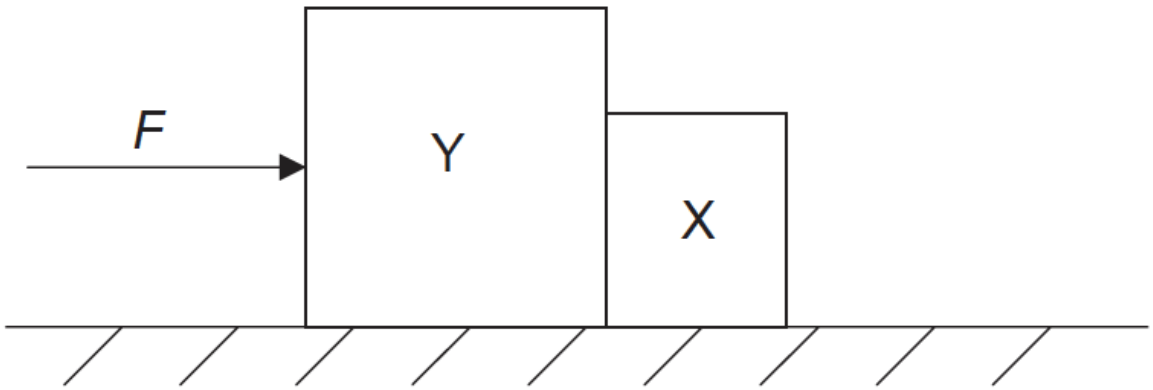
A. The object must be stationary.

B. The object must be moving with constant acceleration.

C. The resultant force acting on the object must be zero.

D. There must be no external forces acting on the object.

9. A constant horizontal force *F* is applied to a block Y. Block Y is in contact with a separate block X. *[1 mark]*



The blocks remain in contact as they accelerate along a horizontal frictionless surface. Y has a greater mass than X. Air resistance is negligible.

Which statement is correct?

A. The force *F* is equal to the product of the mass of Y and the acceleration of Y.

B. The force that Y exerts on X is less than *F*.

C. The force that Y exerts on X is less than the force that X exerts on Y.

D. The force that Y exerts on X is equal to *F*.

10. A body moves in a straight line. In order for the equations for uniformly accelerated motion to be applied, which condition **must** be true? *[1 mark]*

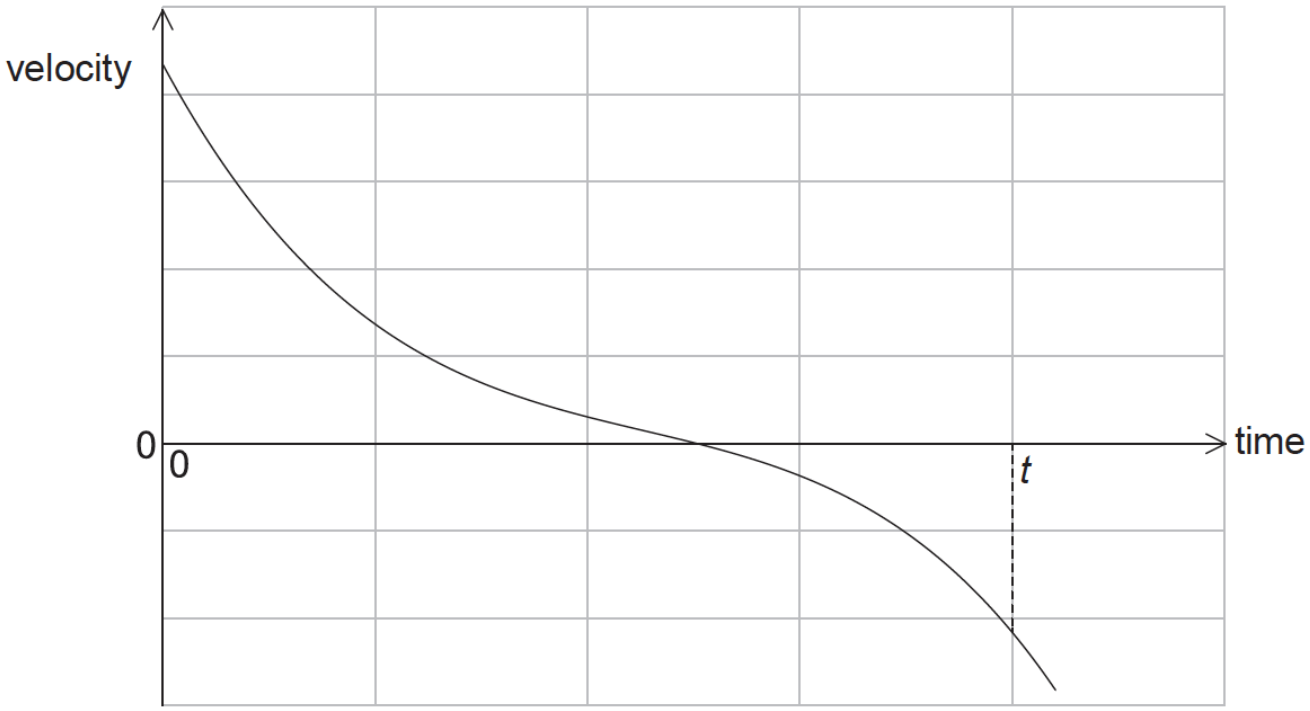
A. A constant net force acts on the body of fixed mass.

B. A constant net force acts on the body.

C. The body falls towards the surface of a planet.

D. The body has an initial velocity of zero.

11. The graph shows the variation with time of the velocity of a truck of fixed mass. *[1 mark]*



What can be deduced from the graph?

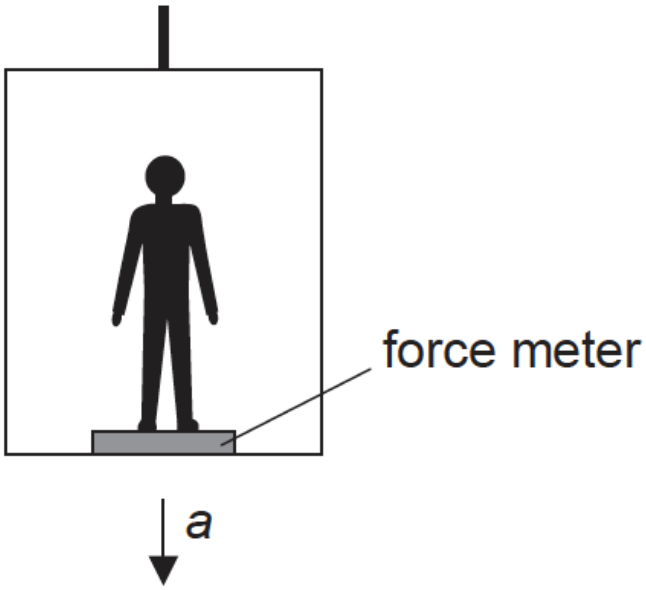
A. The truck is always accelerating.

B. The truck is always moving.

C. The truck is always moving in one direction.

D. The displacement of the truck after time *t* is zero.

12. A student of mass *m* is in an elevator which is accelerating downwards at an acceleration *a*. *[1 mark]*



What is the reading on the force meter?

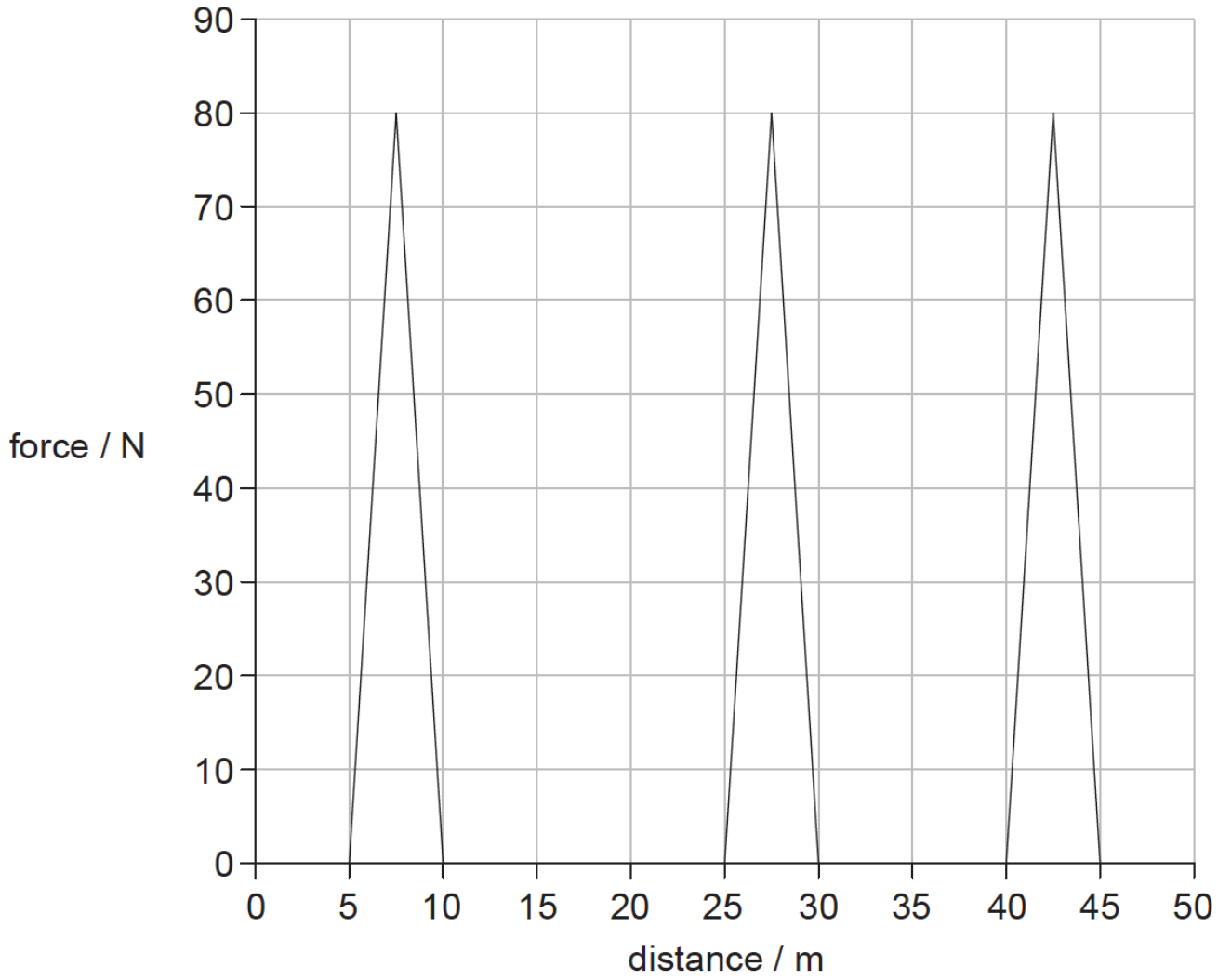
A. mg

B. $mg - ma$

C. $mg + ma$

D. $ma - mg$

13. A girl is standing on a moving skateboard. She pushes backwards on the ground at intervals as shown on the graph. *[1 mark]*



How much kinetic energy is gained by the girl during the period represented on the graph? Frictional forces are negligible.

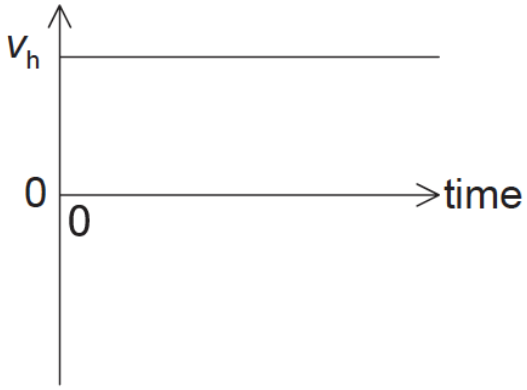
A. 200 J

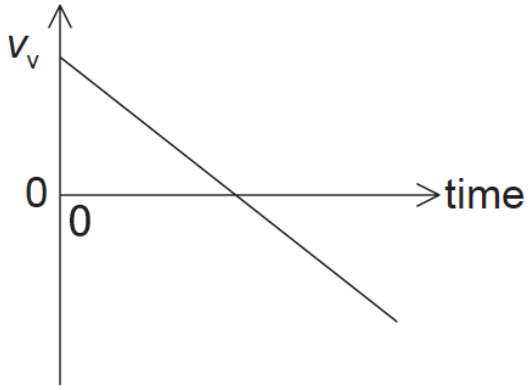
B. 400 J

C. 600 J

D. 1200 J

14. The horizontal component v_h and the vertical component v_v of velocity of an object are shown on the graphs. Air resistance is negligible. *[1 mark]*





These graphs could represent the motion of an object fired from a cliff

A. vertically upwards.

B. at an angle above the horizontal.

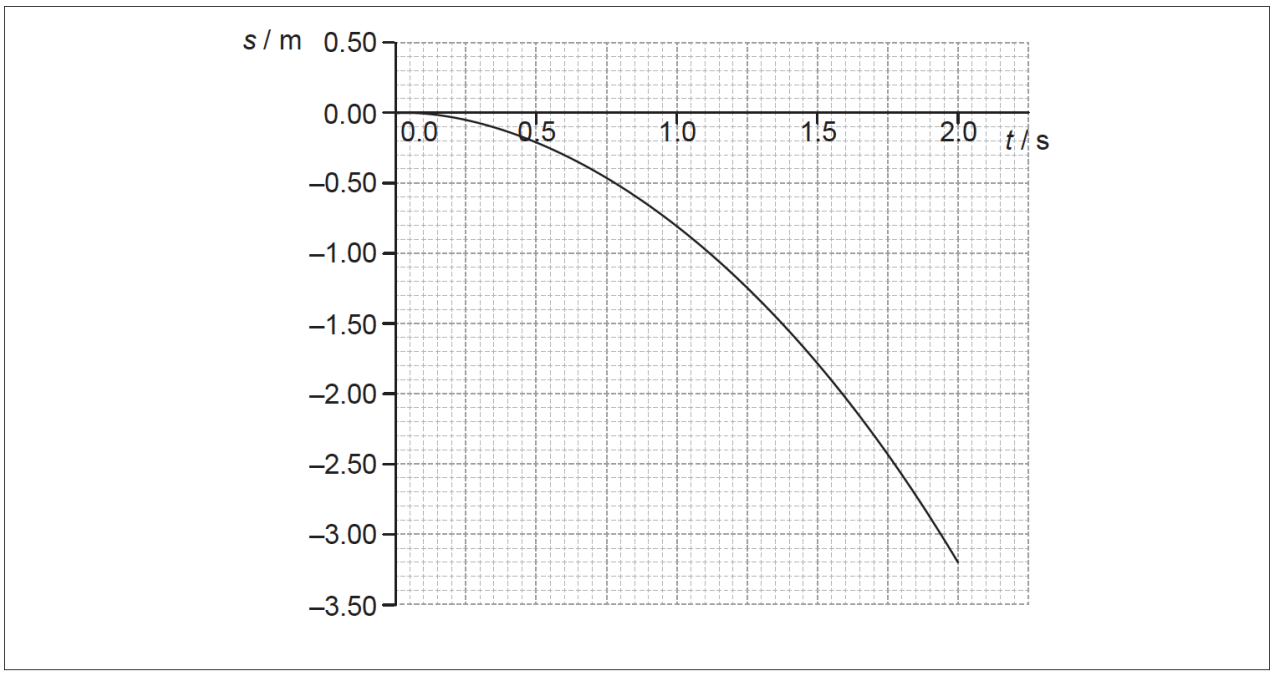
C. horizontally.

D. at an angle below the horizontal.

This question is in **two** parts. **Part 1** is about kinematics and gravitation. **Part 2** is about radioactivity.

Part 1 Kinematics and gravitation

A ball is released near the surface of the Moon at time $t=0$. The point of release is on a straight line between the centre of Earth and the centre of the Moon. The graph below shows the variation with time t of the displacement s of the ball from the point of release.



15a. State the significance of the negative values of s. *[1 mark]*

15b. Use the graph to *[6 marks]*

(i) estimate the velocity of the ball at $t = 0.80$ s.

(ii) calculate a value for the acceleration of free fall close to the surface of the Moon.

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15c. The following data are available. *[4 marks]*

Mass of the ball = 0.20 kg

Mean radius of the Moon = 1.74×10^6 m

Mean orbital radius of the Moon about the centre of Earth = 3.84×10^8 m

Mass of Earth = 5.97×10^{24} kg

Show that Earth has no significant effect on the acceleration of the ball.

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15d. Calculate the speed of an identical ball when it falls 3.0 m from rest close to the surface of Earth. Ignore air resistance. *[1 mark]*

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15e. Sketch, on the graph, the variation with time t of the displacement s from the point of release of the ball when the ball is dropped close to the surface of Earth. (For this sketch take the direction towards the Earth as being negative.) *[3 marks]*

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Part 2 Radioactivity

Two isotopes of calcium are calcium-40 $\left(\frac{40}{20}\mathrm{Ca}\right)$ and calcium-47 $\left(\frac{47}{20}\mathrm{Ca}\right)$. Calcium-40 is stable and calcium-47 is radioactive with a half-life of 4.5 days.

15f. Calculate the percentage of a sample of calcium-47 that decays in 27 days. *[3 marks]*

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15g. The nuclear equation for the decay of calcium-47 into scandium-47 $\left(^{47}_{21}\mathrm{Sc}\right)$ is given by *[4 marks]*

$$^{47}_{20}\mathrm{Ca} \rightarrow {}^{47}_{21}\mathrm{Sc} + {}^{0}_{-1}\mathrm{e} + \mathrm{X}$$

(i) Identify X.

(ii) The following data are available.

Mass of calcium-47 nucleus = 46.95455 u
Mass of scandium-47 nucleus = 46.95241 u

Using the data, determine the maximum kinetic energy, in MeV, of the products in the decay of calcium-47.

(iii) State why the kinetic energy will be less than your value in (h)(ii).

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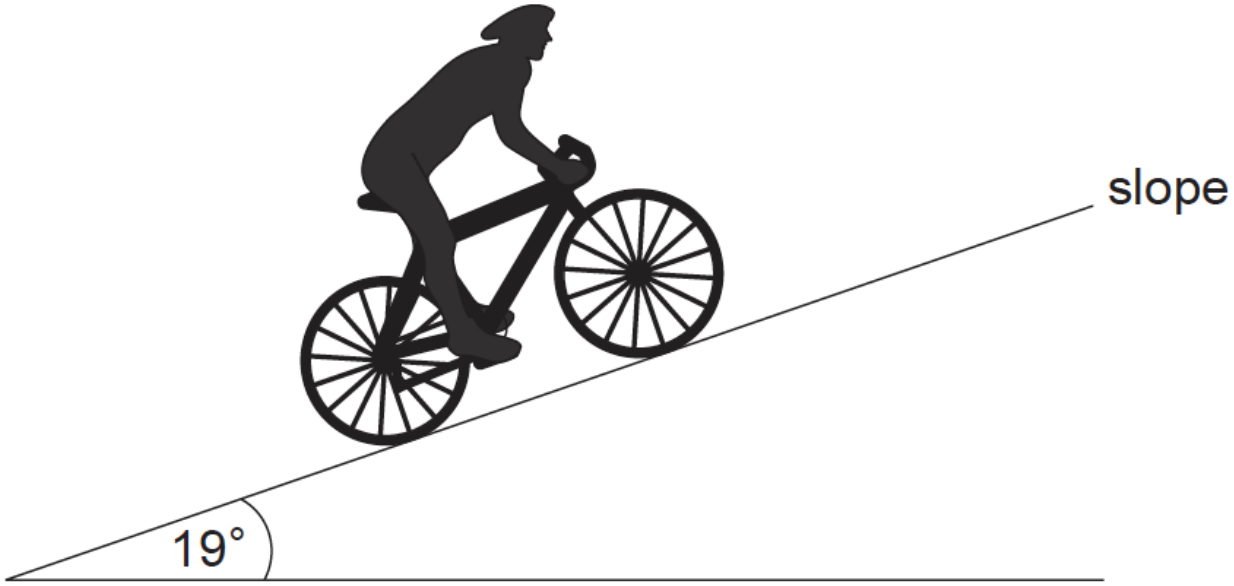
This question is about the motion of a bicycle.

A cyclist is moving up a slope that is at an angle of 19° to the horizontal. The mass of the cyclist and the bicycle is 85 kg.



16a. Calculate the *[3 marks]*

(i) component of the weight of the cyclist and bicycle parallel to the slope.

(ii) normal reaction force on the bicycle from the slope.

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16b. At the bottom of the slope the cyclist has a speed of 5.5ms^{-1}. The cyclist stops pedalling and applies the brakes which provide an additional decelerating force of 250 N. Determine the distance taken for the cyclist to stop. Assume air resistance is negligible and that there are no other frictional forces. *[4 marks]*

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This question is in two parts. **Part 1** is about momentum. **Part 2** is about electric point charges.

Part 1 Momentum

17a. State the law of conservation of linear momentum. *[2 marks]*

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17b. Two identical toy cars, A and B are dropped from the same height onto a solid floor without rebounding. Car A is unprotected whilst car B is in a box with protective packaging around the toy. Explain why car B is less likely to be damaged when dropped. *[4 marks]*

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Part 2 Electric point charges

17c. Define *electric field strength* at a point in an electric field. *[2 marks]*

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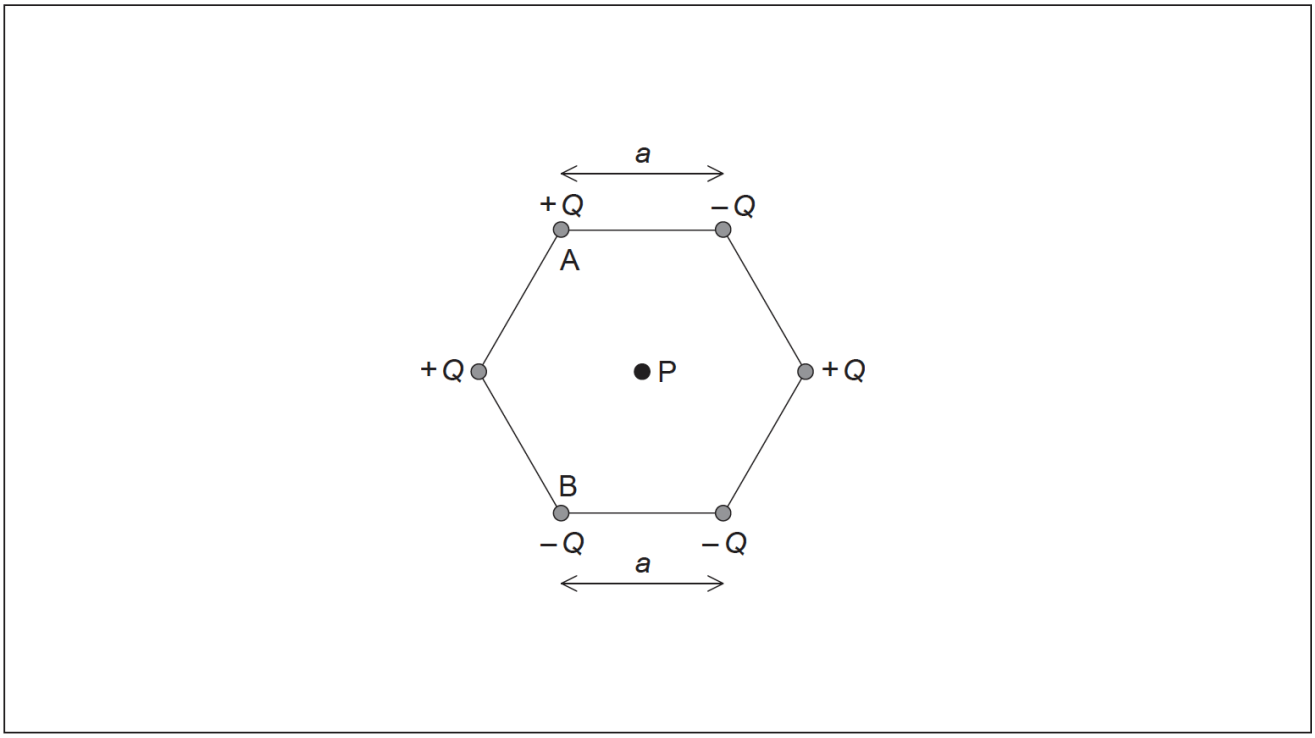
17d. Six point charges of equal magnitude Q are held at the corners of a hexagon with the signs of the charges as shown. Each side of the hexagon has a length a. *[8 marks]*



P is at the centre of the hexagon.

(i) Show, using Coulomb's law, that the magnitude of the electric field strength at point P due to **one** of the point charges is

$$\frac{kQ}{a^2}$$

(ii) On the diagram, draw arrows to represent the direction of the field at P due to point charge A (label this direction A) and point charge B (label this direction B).

(iii) The magnitude of Q is 3.2 μC and length a is 0.15 m. Determine the magnitude and the direction of the electric field strength at point P due to all six charges.

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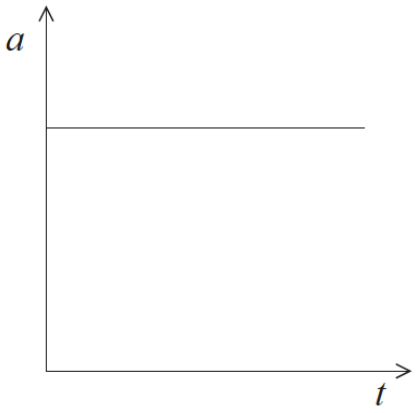
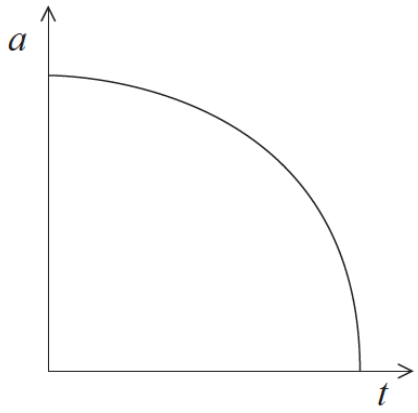
18. An object is dropped from rest above the Earth's surface. Air resistance acts on the object. What is the variation of acceleration a with time t for the object? *[1 mark]*

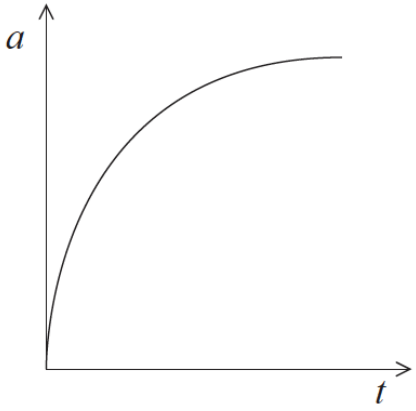
A.



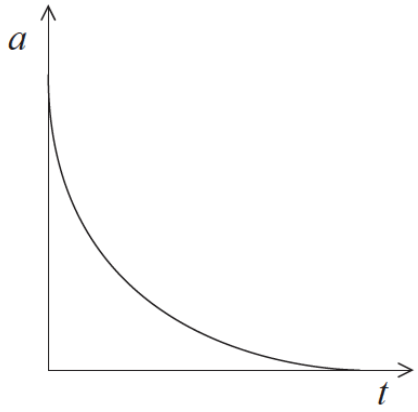
B.



C.



D.



19. Which of the following is a condition for an object to be in translational equilibrium? *[1 mark]*

A. The object must be moving at constant speed.

B. The velocity of the object in any direction must be zero.

C. The forces acting horizontally on the object must equal the forces acting vertically on the object.

D. The resultant force acting on the object must be zero.

20. No external forces act on a given system during an inelastic collision. For this system, which is correct about the conservation of kinetic energy and the conservation of linear momentum? *[1 mark]*

	Kinetic energy	Linear momentum
A.	must be conserved	may be conserved
B.	must be conserved	must be conserved
C.	is not conserved	may be conserved
D.	is not conserved	must be conserved

21. An object of mass m_1 has a kinetic energy E_1. Another object has a mass m_2 and kinetic energy E_2. The objects have the same momentum. What is the ratio $\frac{E_1}{E_2}$? *[1 mark]*

A. 1

B. $\sqrt{\frac{m_2}{m_1}}$

C. $\frac{m_2}{m_1}$

D. $\left(\frac{m_2}{m_1}\right)^2$

22. A metal sphere is at rest on a bench. According to Newton's third law of motion, what is a possible action-reaction pair for this situation? *[1 mark]*

	Action	Reaction
A.	downwards gravitational force of Earth on the sphere	upwards gravitational force of the sphere on Earth
B.	upwards gravitational force of Earth on the sphere	downwards gravitational force of the sphere on Earth
C.	upwards electrostatic force acting on the sphere due to the atoms in the bench surface	upwards gravitational force of the sphere on Earth
D.	upwards electrostatic force acting on the sphere due to the atoms in the bench surface	downwards gravitational force of the sphere on Earth

23. Which of the following is a condition for an object to be in translational equilibrium? *[1 mark]*

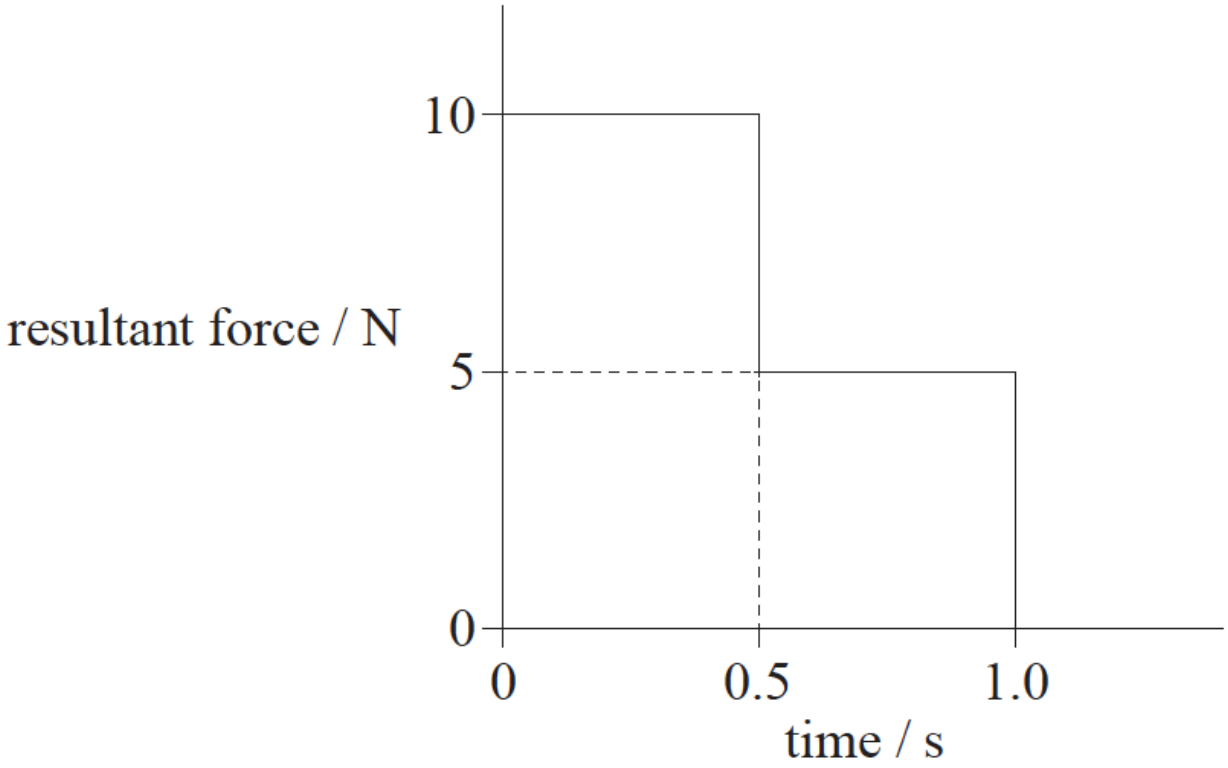
A. The object must be moving at constant speed.

B. The velocity of the object in any direction must be zero.

C. The forces acting horizontally on the object must equal the forces acting vertically on the object.

D. The resultant force acting on the object must be zero.

24. The resultant force acting on an object of mass 5.0kg varies with time as shown. The object is initially at rest. *[1 mark]*



What is the speed of the object after 1.0 s?

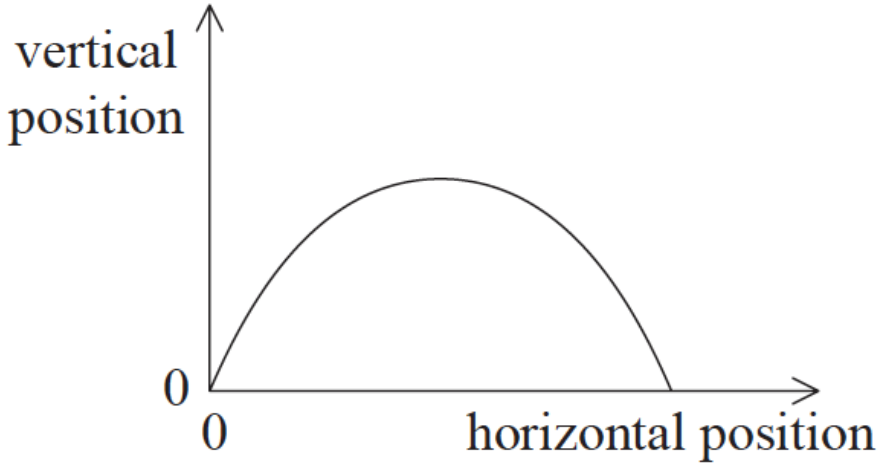
A. 0.50ms^{-1}

B. 1.0ms^{-1}

C. 1.5ms^{-1}

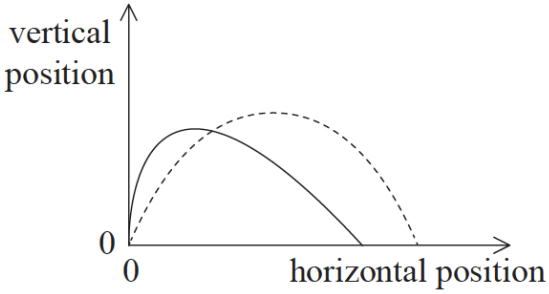
D. 2.0ms^{-1}

25. The diagram shows the trajectory of an object projected in the absence of air resistance. *[1 mark]*



The object is then projected with the same initial conditions but air resistance is taken into account. Which of the following is the trajectory when air resistance is taken into account? The original trajectory is shown as a dotted line.

A.



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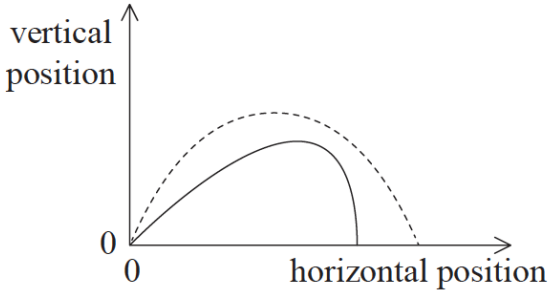
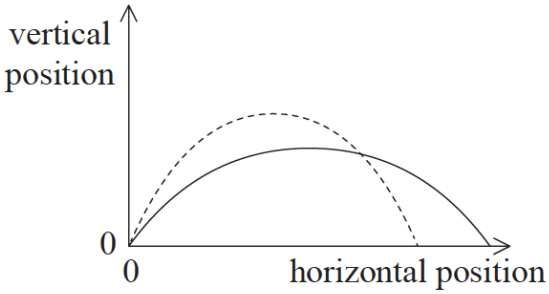
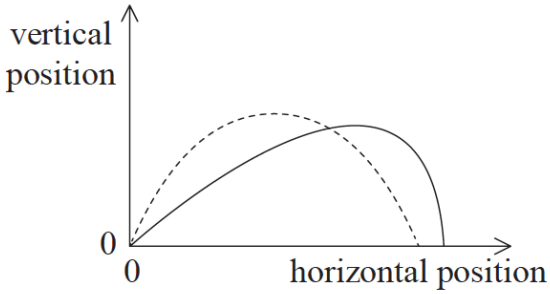


C.

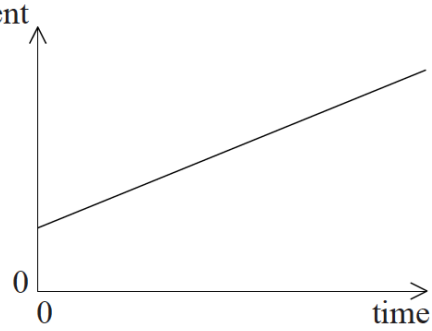


D.

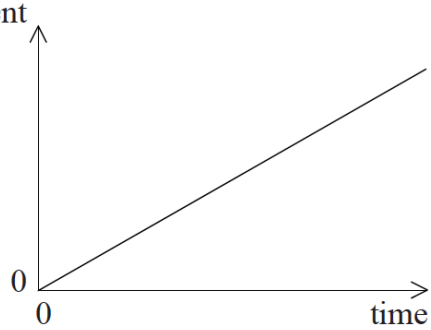


26. A body moves on a straight line. The graphs show the variation of displacement with time. Which graph shows motion with negative acceleration? *[1 mark]*

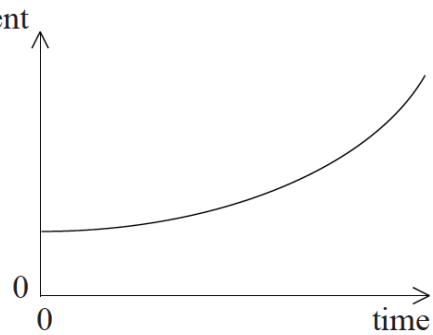
A.



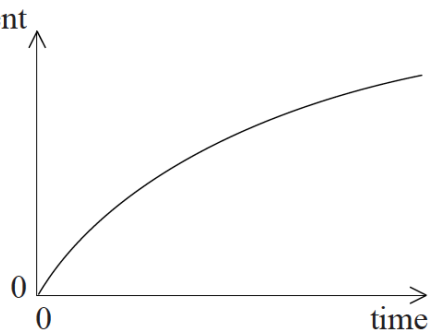
B.



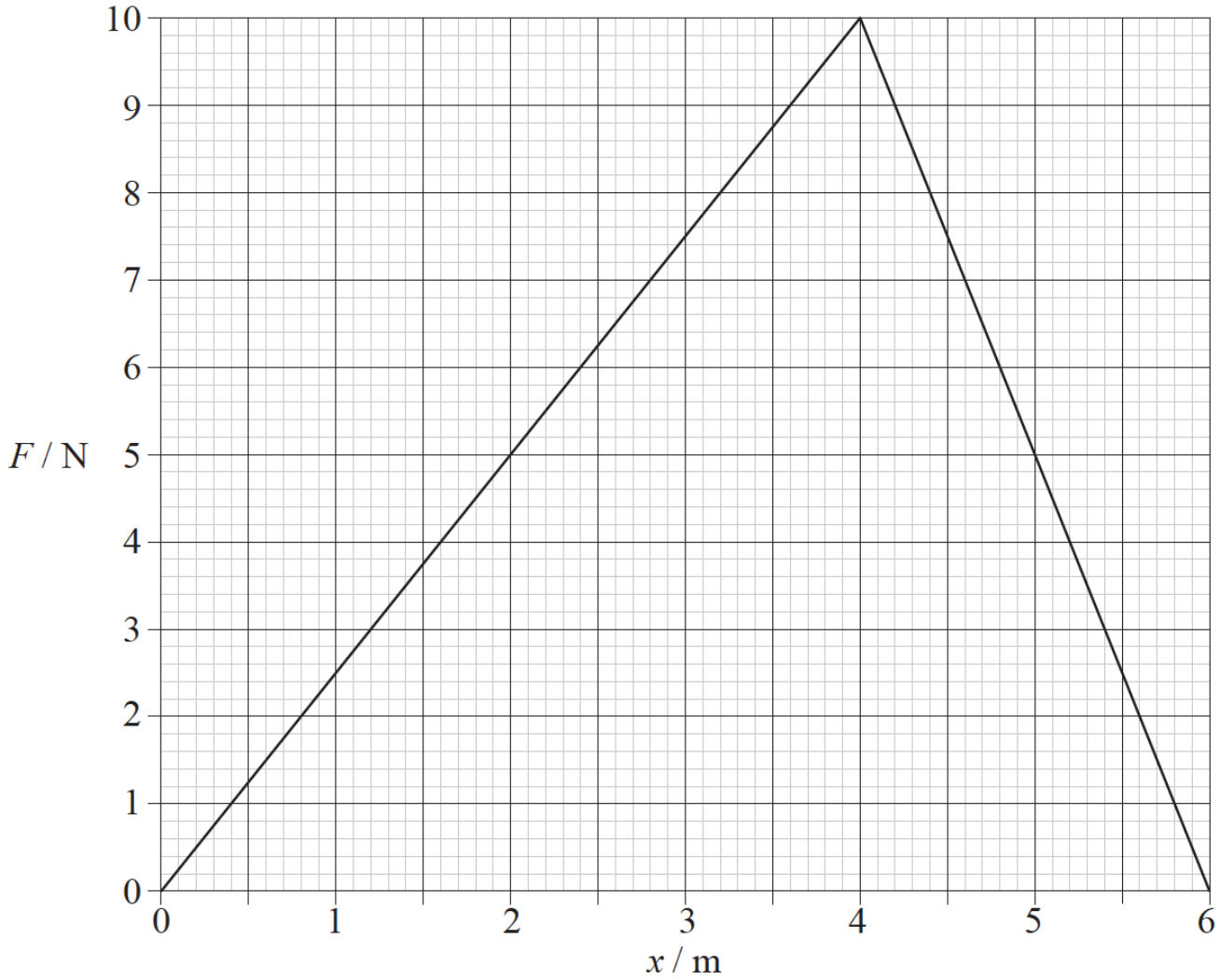
C.



D.



27. The graph shows how the net force F that acts on a body varies with the distance x that the body has travelled. *[1 mark]*



After travelling 6 m, the change in the kinetic energy of the body is

A. 0 J.
B. 20 J.
C. 30 J.
D. 60 J.

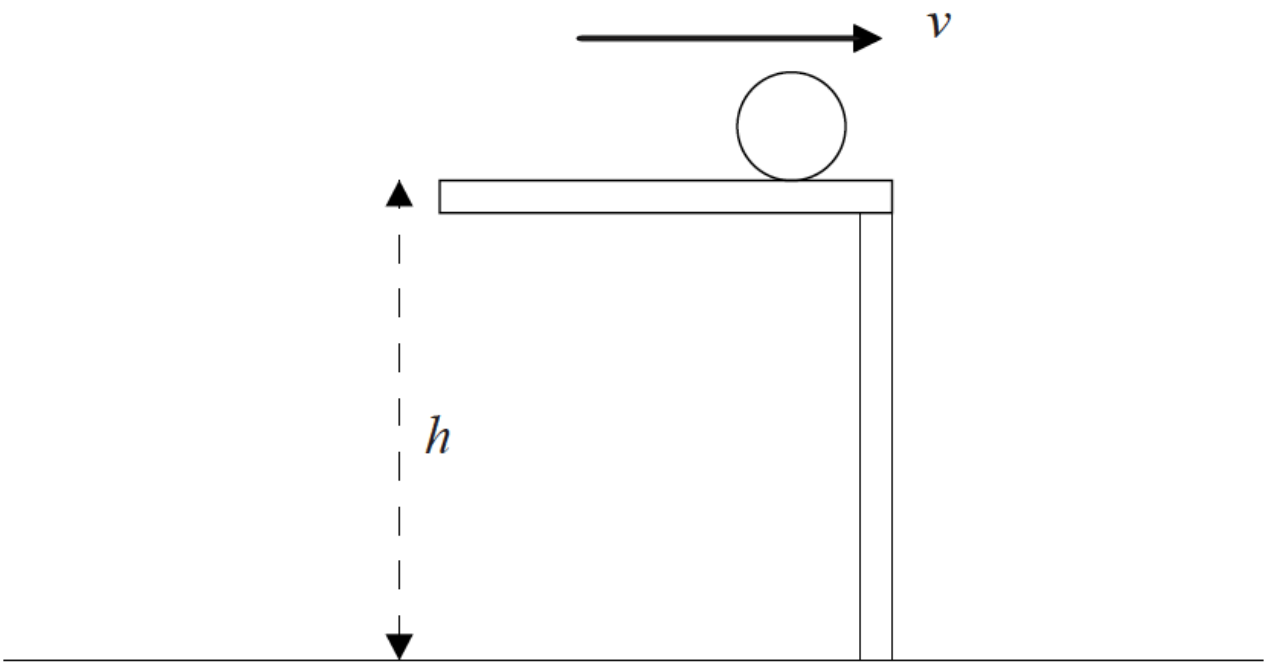
28. A constant force of 12 N is applied for 3.0 s to a body initially at rest. The final velocity of the body is 6.0m s^{-1}. *[1 mark]*
What is the mass of the body?

A. 1.5 kg
B. 6.0 kg
C. 24 kg
D. 36 kg

29. A cart of mass 4.0 kg is being pulled with a force of 24 N. The cart accelerates at 3.0m s^{-2}. What is the net force on *[1 mark]*
the cart?

A. 6.0 N
B. 8.0 N
C. 12 N
D. 24 N

30. A ball of mass *m* is projected horizontally with speed *v* from a height *h* above the floor. Air resistance is negligible. *[1 mark]*



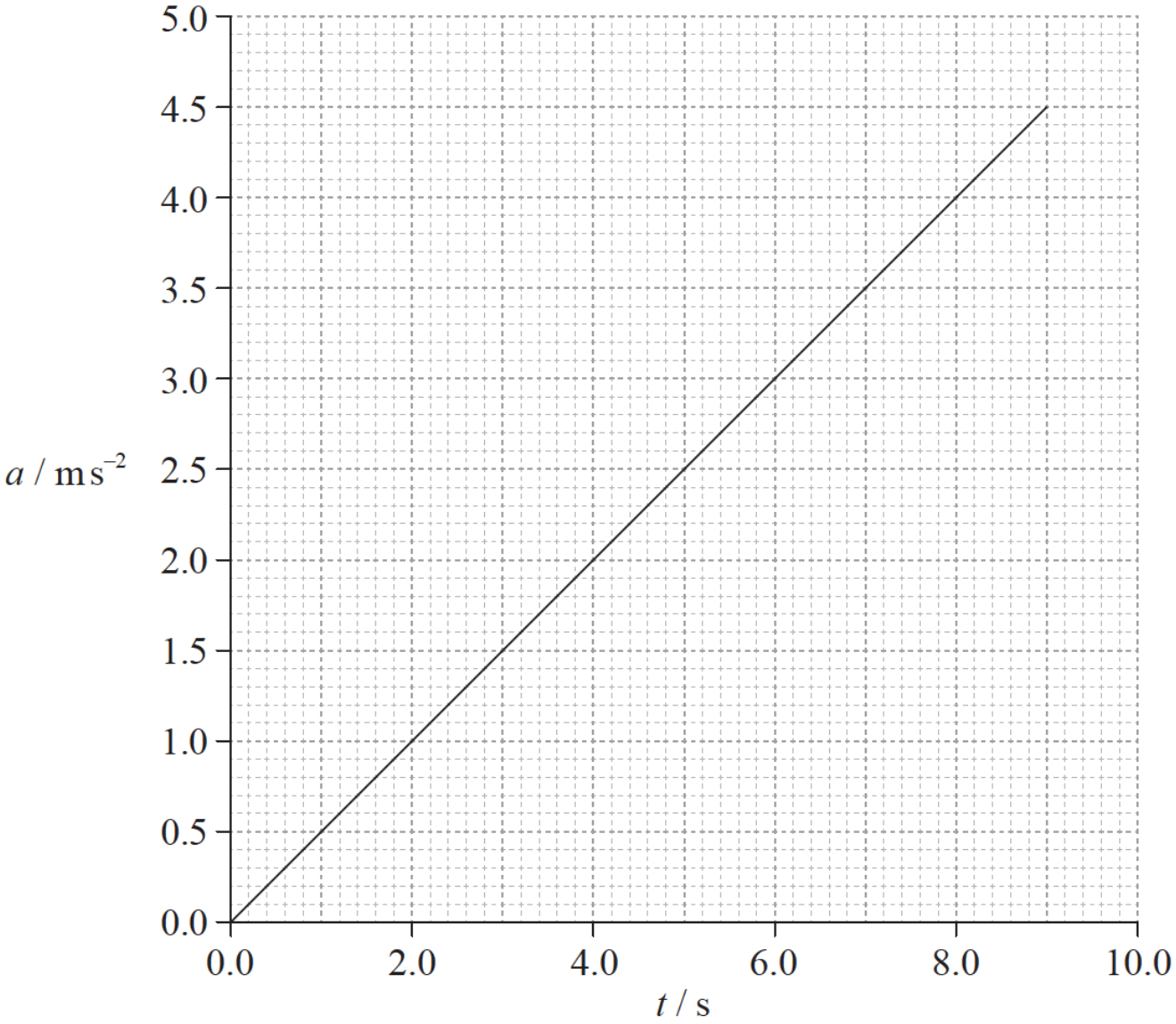
The horizontal distance travelled by the ball to the point where it lands on the floor depends on

A. *m* and *h* only.
B. *m* and *v* only.
C. *h* and *v* only.
D. *m*, *h* and *v*.

31. Each side of a metal cube is measured to be 2.0 cm ± 0.20 cm. What is the absolute uncertainty in the calculated volume of the cube? *[1 mark]*

A. ± 0.08 cm^3
B. ± 0.60 cm^3
C. ± 0.80 cm^3
D. ± 2.4 cm^3

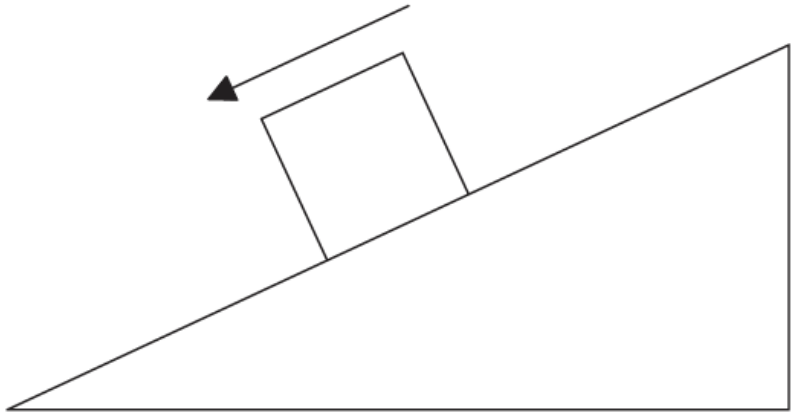
32. A particle accelerates from rest. The graph shows how the acceleration a of the particle varies with time t. *[1 mark]*



What is the speed of the particle at t=6.0s?

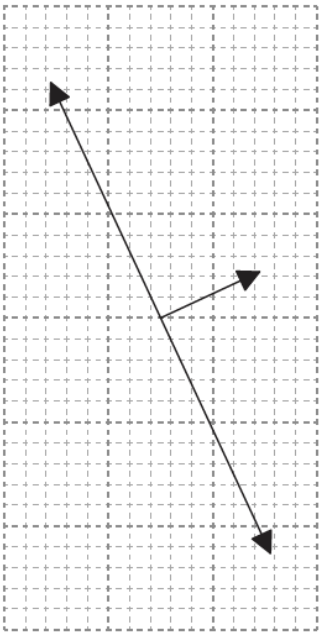
A. 0.5 ms^{-1}
B. 2.0 ms^{-1}
C. 9.0 ms^{-1}
D. 18 ms^{-1}

33. A block slides down an inclined plane at constant speed. *[1 mark]*

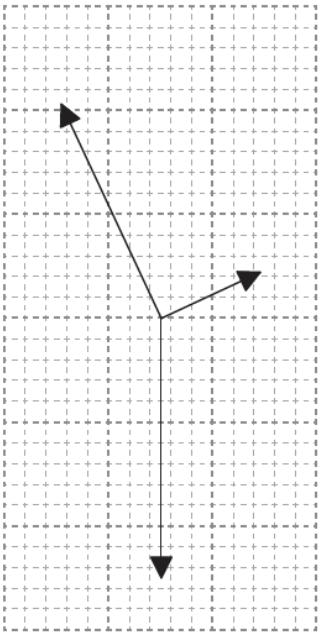


Which diagram represents the free-body diagram of the forces acting on the block?

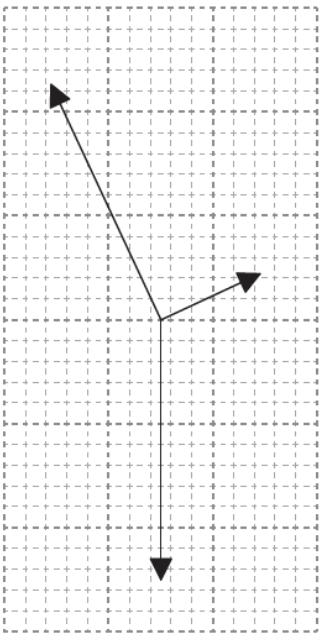
A.



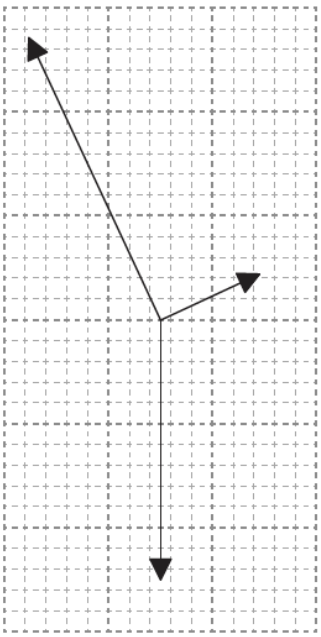
B.



C.



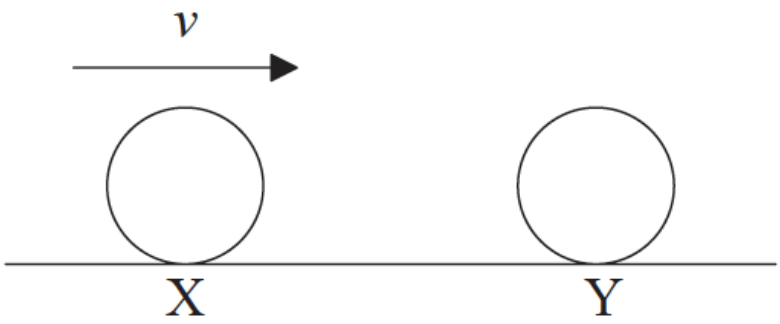
D.



34. In the collision between two bodies, Newton's third law *[1 mark]*

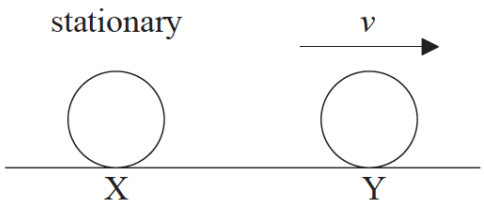
A. only applies if momentum is conserved in the collision.
B. only applies if energy is conserved in the collision.
C. only applies if both momentum and energy are conserved in the collision.
D. always applies.

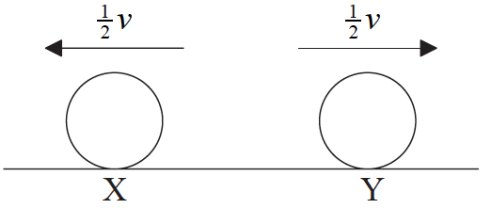
35. A ball X moving horizontally collides with an identical ball Y that is at rest. *[1 mark]*

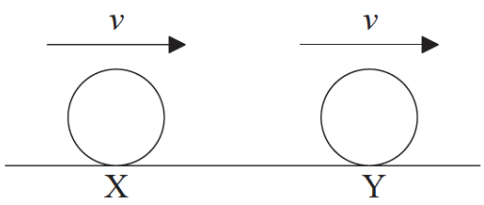


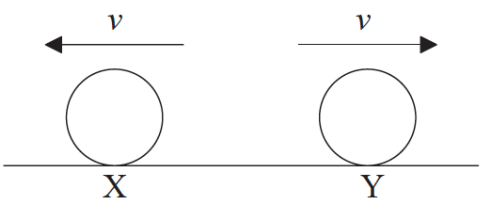
X strikes Y with speed *v*.

What is a possible outcome of the collision?

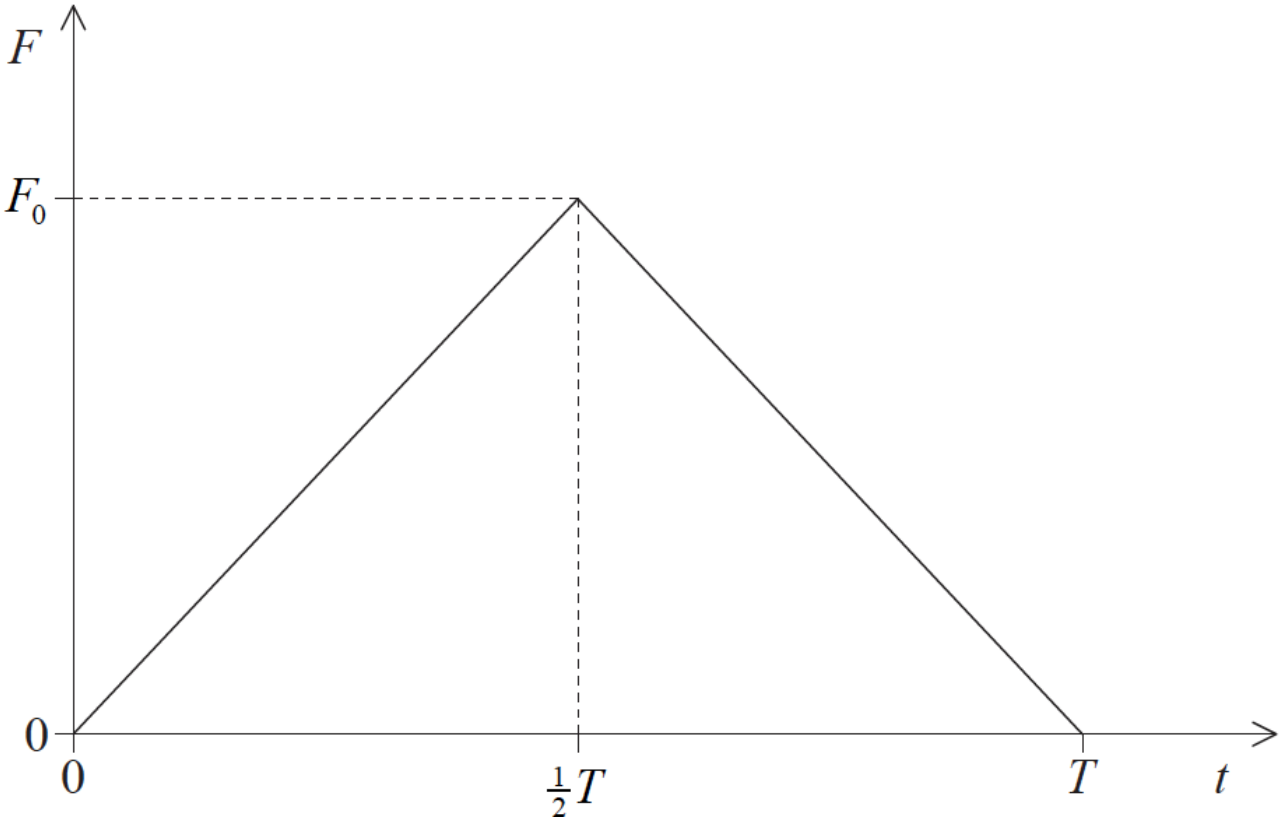
A.


B.


C.


D.


36. A ball is moving horizontally and strikes a vertical wall from which it rebounds horizontally. The sketch graph shows how the contact force *F* between ball and wall varies with time of contact *t*. *[1 mark]*



The maximum value of *F* is F_0 and the total time of contact between ball and wall is *T*.

What is the change in momentum of the ball?

A. $\frac{F_0 T}{2}$

B. $F_0 T$

C. $\frac{F_0}{2T}$

D. $\frac{F_0}{T}$

37. An insect of mass *m* jumps vertically from rest to a height *h*. The insect releases the energy needed for the jump in time Δt. What is the estimate for the power developed by the insect? *[1 mark]*

A. $mgh\ \Delta t$

B. $mh\ \Delta t$

C. $\frac{mgh}{\Delta t}$

D. $\frac{mh}{\Delta t}$

38. A truck is pulled up an inclined plane at constant speed by an electric motor. The gain in potential energy of the truck is 48 kJ. The efficiency of the electric motor is $\frac{2}{3}$. *[1 mark]*

How much energy is dissipated in pulling the truck up the plane?

A. 16 kJ

B. 24 kJ

C. 32 kJ

D. 64 kJ

39. A projectile is fired from level ground with speed v at an angle θ to the ground. Ignoring air resistance, which of the following is a correct expression for the maximum height reached by the projectile? *[1 mark]*

A. $\frac{v^2 \sin^2 \theta}{2g}$

B. $\frac{v^2 \cos^2 \theta}{2g}$

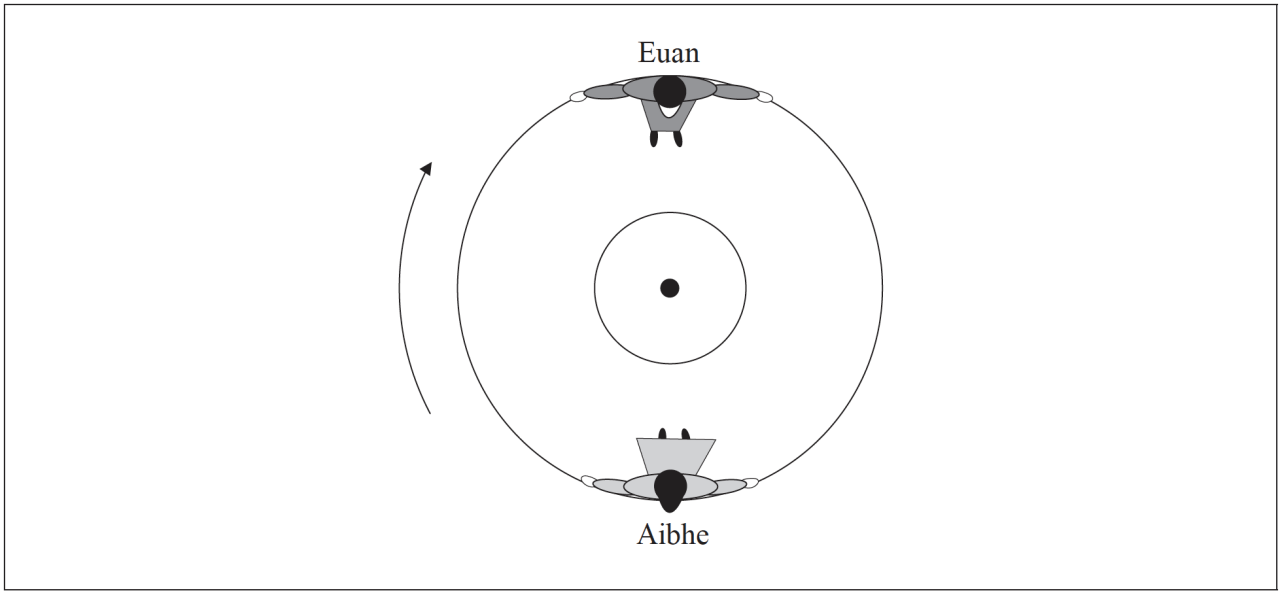
C. $\frac{v \sin \theta}{g}$

D. $\frac{v \cos \theta}{g}$

This question is in **two** parts. **Part 1** is about two children on a merry-go-round. **Part 2** is about electric circuits.

Part 1 Two children on a merry-go-round

Aibhe and Euan are sitting on opposite sides of a merry-go-round, which is rotating at constant speed around a fixed centre. The diagram below shows the view from above.



Aibhe is moving at speed 1.0ms^{-1} relative to the ground.

40a. Determine the magnitude of the velocity of Aibhe relative to *[2 marks]*

(i) Euan.

(ii) the centre of the merry-go-round.

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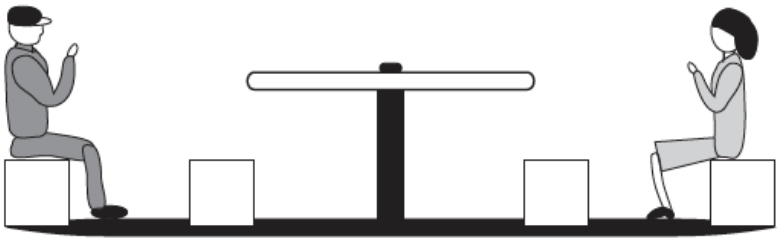
40b. (i) Outline why Aibhe is accelerating even though she is moving at constant speed. *[6 marks]*

(ii) Draw an arrow on the diagram on page 22 to show the direction in which Aibhe is accelerating.

(iii) Identify the force that is causing Aibhe to move in a circle.

(iv) The diagram below shows a side view of Aibhe and Euan on the merry-go-round.



Explain why Aibhe feels as if her upper body is being "thrown outwards", away from the centre of the merry-go-round.

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40c. Euan is rotating on a merry-go-round and drags his foot along the ground to act as a brake. The merry-go-round comes to a stop after 4.0 rotations. The radius of the merry-go-round is 1.5 m. The average frictional force between his foot and the ground is 45 N. Calculate the work done. *[2 marks]*

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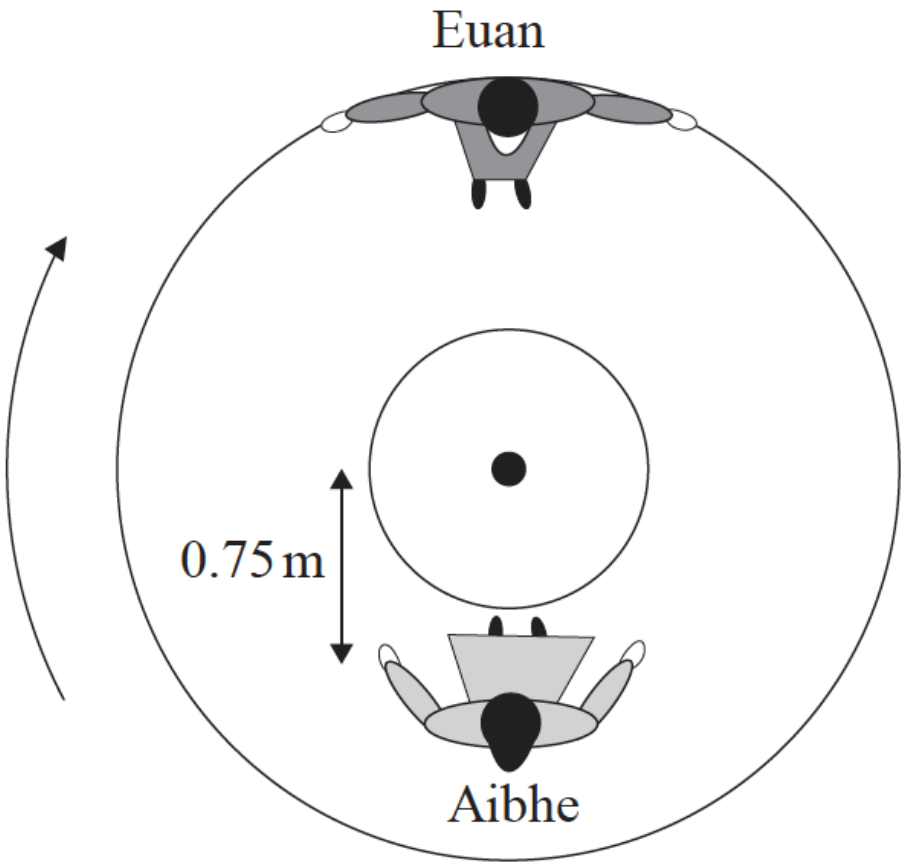
40d. Aibhe moves so that she is sitting at a distance of 0.75 m from the centre of the merry-go-round, as shown below. *[5 marks]*



Euan pushes the merry-go-round so that he is again moving at 1.0 ms^{-1} relative to the ground.

(i) Determine Aibhe's speed relative to the ground.

(ii) Calculate the magnitude of Aibhe's acceleration.

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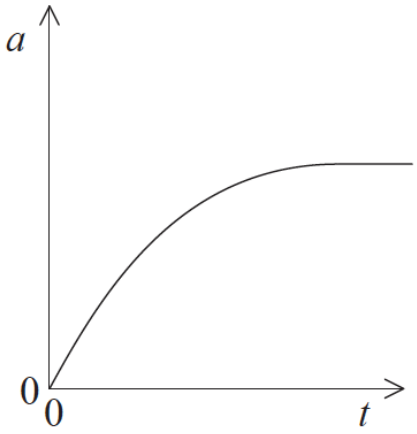
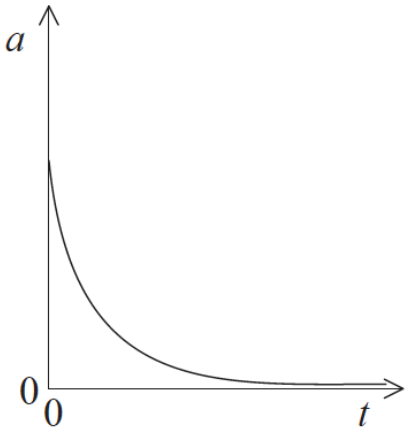
41. A tennis ball is dropped from the top of a high building. Air resistance **cannot** be neglected. Which graph represents the variation with time *t* of the magnitude of the acceleration *a* of the ball before it hits the ground? *[1 mark]*

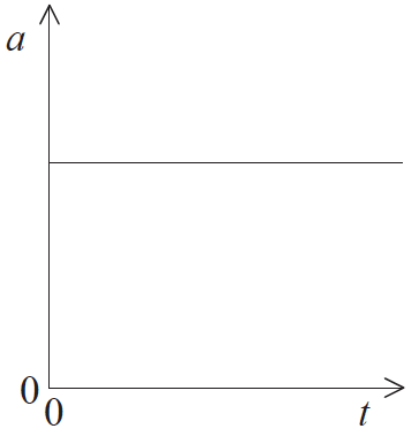
A.



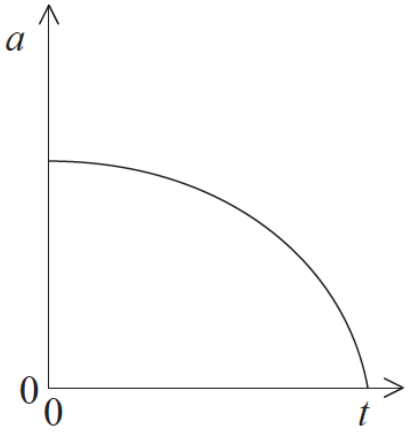
B.



C.

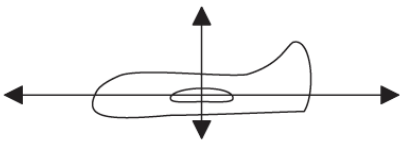


D.

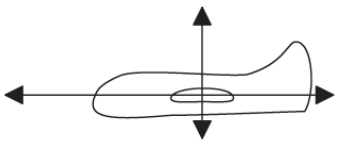


42. A model plane flies with constant velocity at constant height. Which diagram represents the forces acting on the plane? *[1 mark]*

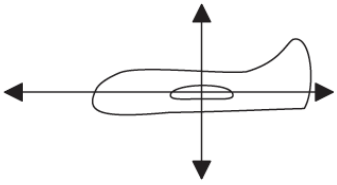
A.



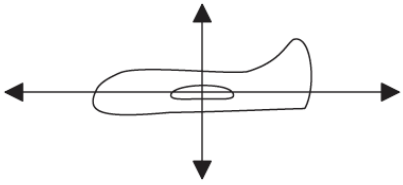
B.



C.



D.



43. The net force on a body is *F*. The impulse of *F* is equal to the *[1 mark]*

A. change in momentum of the body.
B. rate of change of momentum of the body.
C. change of kinetic energy of the body.
D. change of total energy of the body.

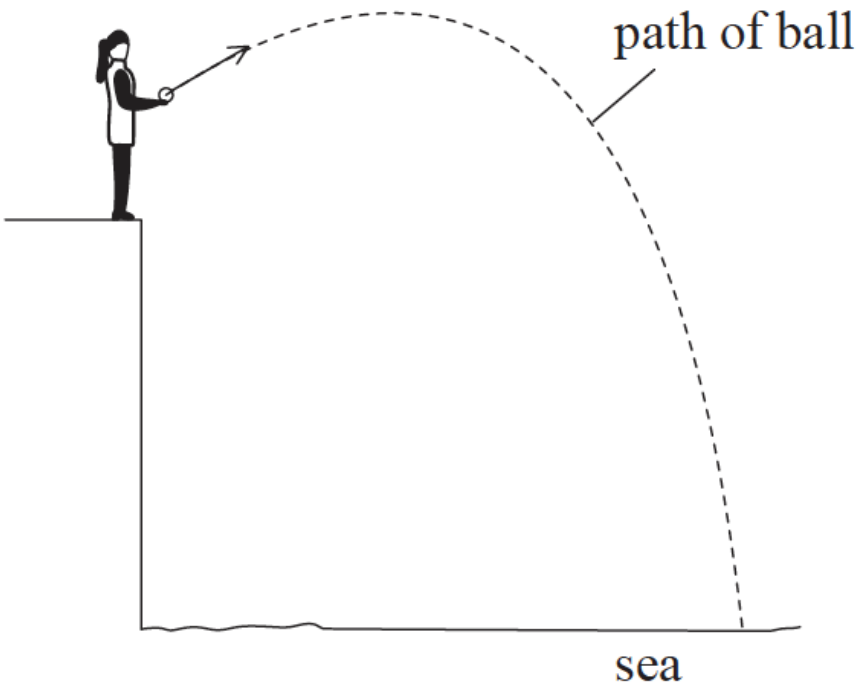
44. In an inelastic collision *[1 mark]*

A. momentum and kinetic energy are both conserved.
B. momentum is conserved but kinetic energy is not.
C. kinetic energy is conserved but momentum is not.
D. neither momentum nor kinetic energy are conserved.

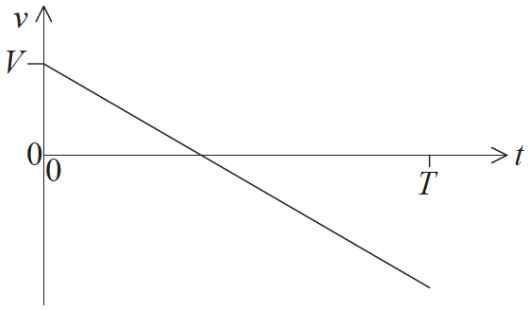
45. A force which increases uniformly from 0 to a maximum value of F is applied to an object. The object does not move until the force exceeds $0.5F$. As the force increases from $0.5F$ to F the object moves a distance x in the direction of the force. What is the work done by this force? *[1 mark]*

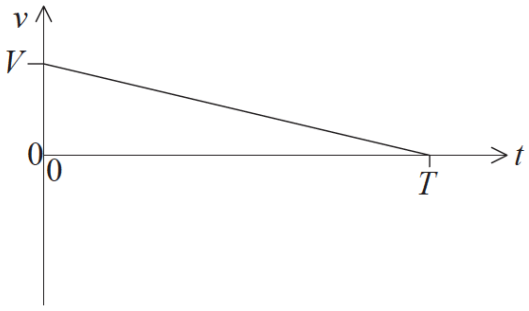
A. $0.25Fx$
B. $0.5Fx$
C. $0.75Fx$
D. Fx

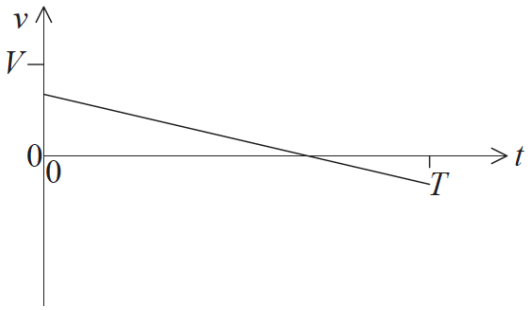
46. A ball is thrown from the top of a cliff. The initial magnitude of the velocity of the ball at time $t=0$ is V. The ball hits the sea at time $t=T$. Air resistance is negligible. *[1 mark]*

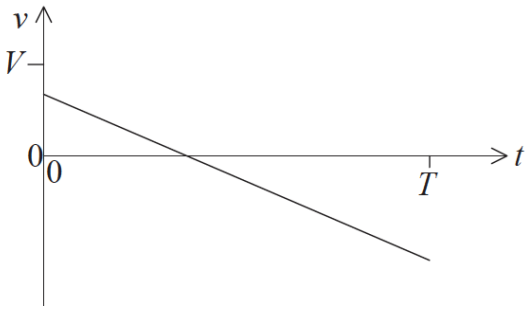


Which graph shows how the **vertical** component of the velocity v of the ball varies with t as it falls to the sea?

A.


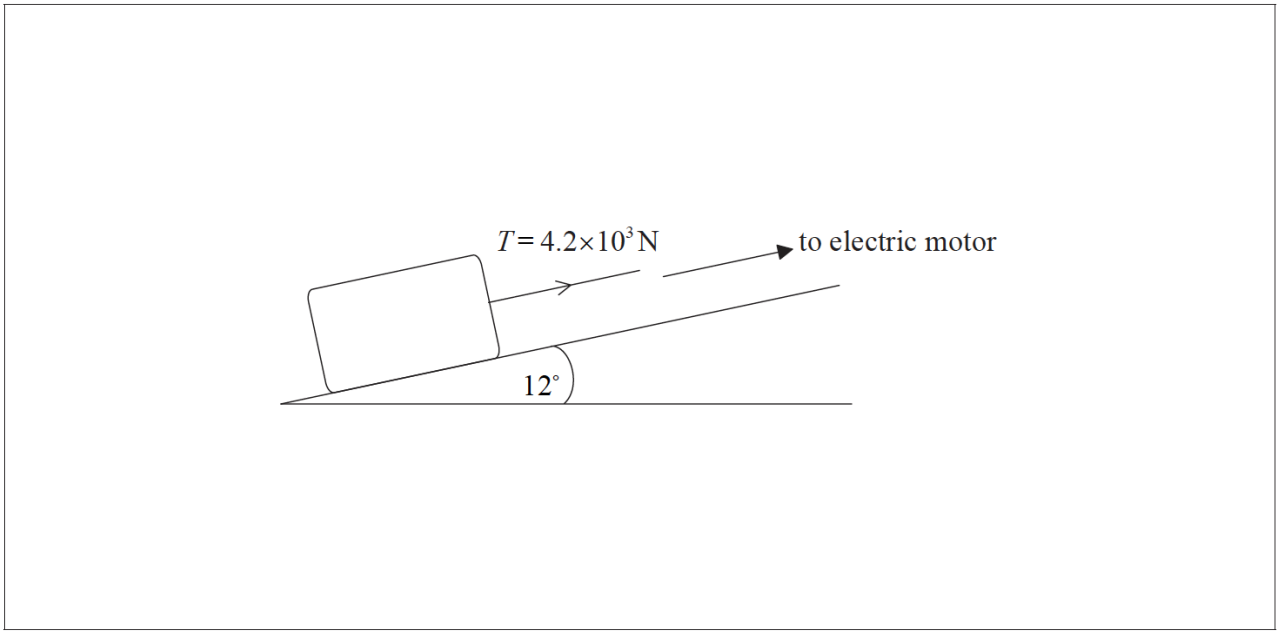
B.


C.


D.


This question is about forces.

A stone block is pulled at constant speed up an incline by a cable attached to an electric motor.



The incline makes an angle of 12° with the horizontal. The weight of the block is 1.5×10^{4}N and the tension T in the cable is 4.2×10^{3}N.

47a. On the diagram draw and label arrows that represent the forces acting on the block. *[2 marks]*

47b. Calculate the magnitude of the friction force acting on the block. *[3 marks]*

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This question is in **two** parts. **Part 1** is about Newton's laws and momentum. **Part 2** is about the greenhouse effect.

Part 1 Newton's laws and momentum

48a. State the condition for the momentum of a system to be conserved. *[1 mark]*

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48b. A person standing on a frozen pond throws a ball. Air resistance and friction can be considered to be negligible. *[5 marks]*

(i) Outline how Newton's third law and the conservation of momentum apply as the ball is thrown.

(ii) Explain, with reference to Newton's second law, why the horizontal momentum of the ball remains constant whilst the ball is in flight.

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48c. The maximum useful power output of a locomotive engine is 0.75 M W. The maximum speed of the locomotive as it travels along a straight horizontal track is 44 m s^{-1}. Calculate the frictional force acting on the locomotive at this speed. *[2 marks]*

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48d. The locomotive engine in (c) gives a truck X a sharp push such that X moves along a horizontal track and collides with a stationary truck Y. As a result of the collision the two trucks stick together and move off with speed *v*. The following data are available. *[4 marks]*

Mass of truck X$=3.7\times10^{3}$ kg
Mass of truck Y$=6.3\times10^{3}$ kg
Speed of X just before collision$=4.0$ m s^{-1}

(i) Calculate *v*.

(ii) Determine the kinetic energy lost as a result of the collision.

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48e. The trucks X and Y come to rest after travelling a distance of 40 m along the horizontal track. Determine the average frictional force acting on X and Y. *[3 marks]*

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Part 2 The greenhouse effect

48f. Nuclear fuels, unlike fossil fuels, produce no greenhouse gases. *[5 marks]*

(i) Identify **two** greenhouse gases.

(ii) Discuss, with reference to the mechanism of infrared absorption, why the temperature of the Earth's surface would be lower if there were no greenhouse gases present in the atmosphere.

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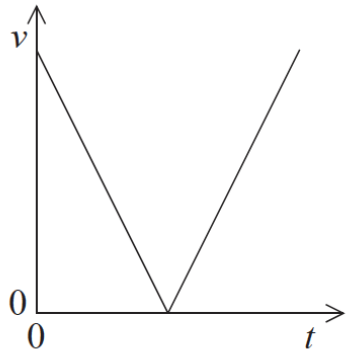
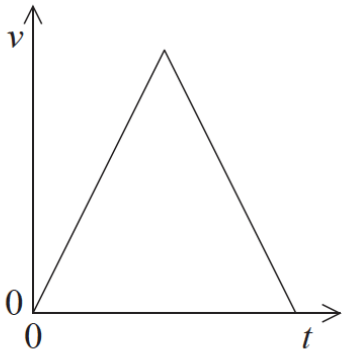
49. An object is thrown upwards leaving the thrower's hand at time t=0. Which graph shows how speed v varies with t *[1 mark]* as the object rises and falls?

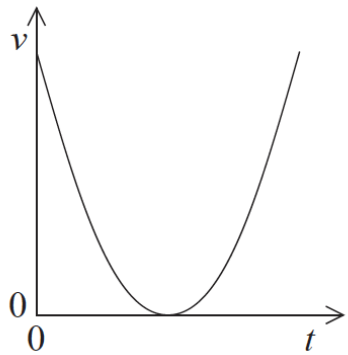
A.



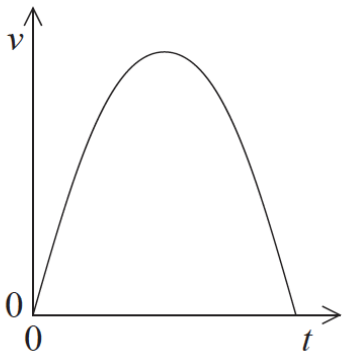
B.



C.



D.



50. A ball of mass m travels horizontally with speed v before colliding with a vertical wall. The ball rebounds at speed v in a direction opposite to its initial direction. What is the magnitude of the change in momentum of the ball? *[1 mark]*

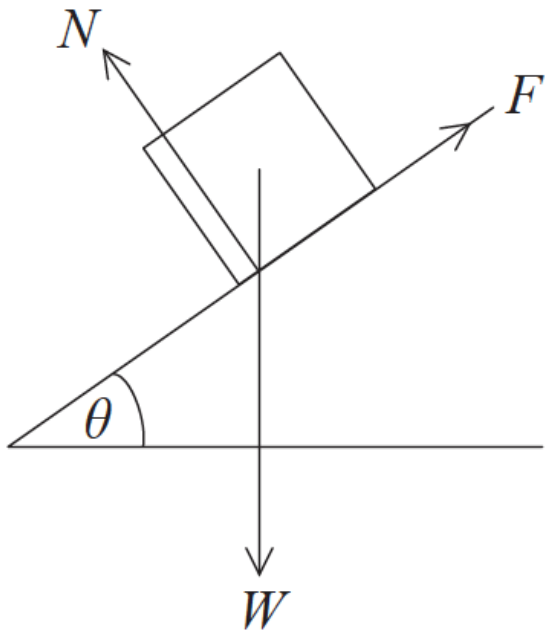
A. 0

B. $\frac{mv}{2}$

C. mv

D. $2mv$

51. A block rests on a plane inclined at an angle θ to the horizontal. Which of the following gives the relationships for the normal reaction N and the frictional force F with the weight W? *[1 mark]*

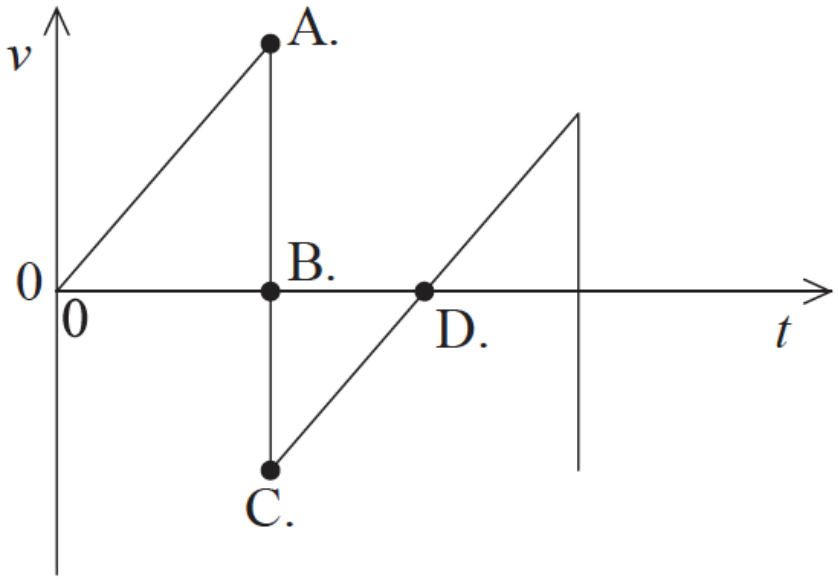


	N	F
A.	$W\sin\theta$	$W\sin\theta$
B.	$W\sin\theta$	$W\cos\theta$
C.	$W\cos\theta$	$W\sin\theta$
D.	$W\cos\theta$	$W\cos\theta$

52. Three coplanar forces of 5 N, 6 N and 7 N act on an object. Which force could **not** be the resultant of these three forces? *[1 mark]*

A. 0 N
B. 11 N
C. 13 N
D. 19 N

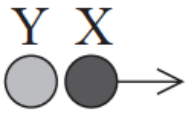
53. A ball is released at time $t=0$ above a horizontal surface. The graph shows the variation of velocity v with time. *[1 mark]*
Which of the following shows the highest point of the ball after one bounce?



54. A driving force F acts on a car which moves with constant velocity v. The quantity Fv is equivalent to the *[1 mark]*

A. useful power developed by the engine of the car.
B. work done by the car against resistive forces.
C. energy of the car.
D. rate of change of momentum of the car.

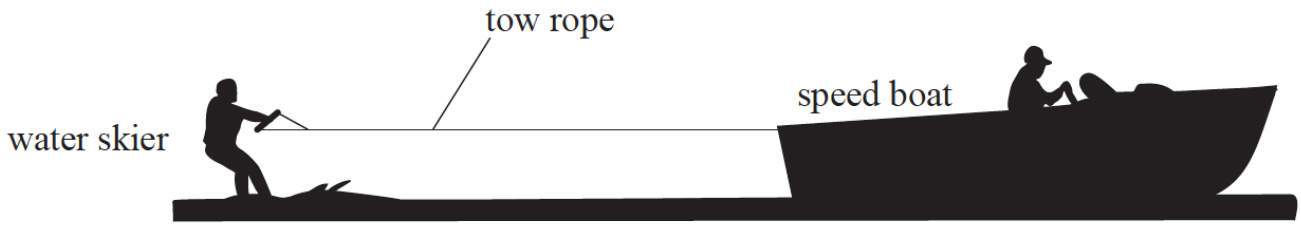
55. Balls X and Y are at the same height. X is projected horizontally at the same time that Y is dropped. Y is the same size as X but has half its mass. *[1 mark]*



Ignoring air resistance, which statement is **true**?

A. Y will hit the ground before X.
B. Y will hit the ground after X.
C. Y will hit the ground at the same time as X.
D. The outcome can only be determined if the initial speed of X is known.

56. A speed boat tows a water skier so that the skier accelerates. *[1 mark]*



The magnitude of the force exerted on the skier by the tow rope must be

I. greater than the magnitude of the total resistive force acting on the skier
II. equal to the magnitude of the force exerted on the tow rope by the skier
III. equal to the magnitude of the force causing the boat to accelerate.

Which of the above factors is/are correct?

A. I and II only
B. I and III only
C. II only
D. III only

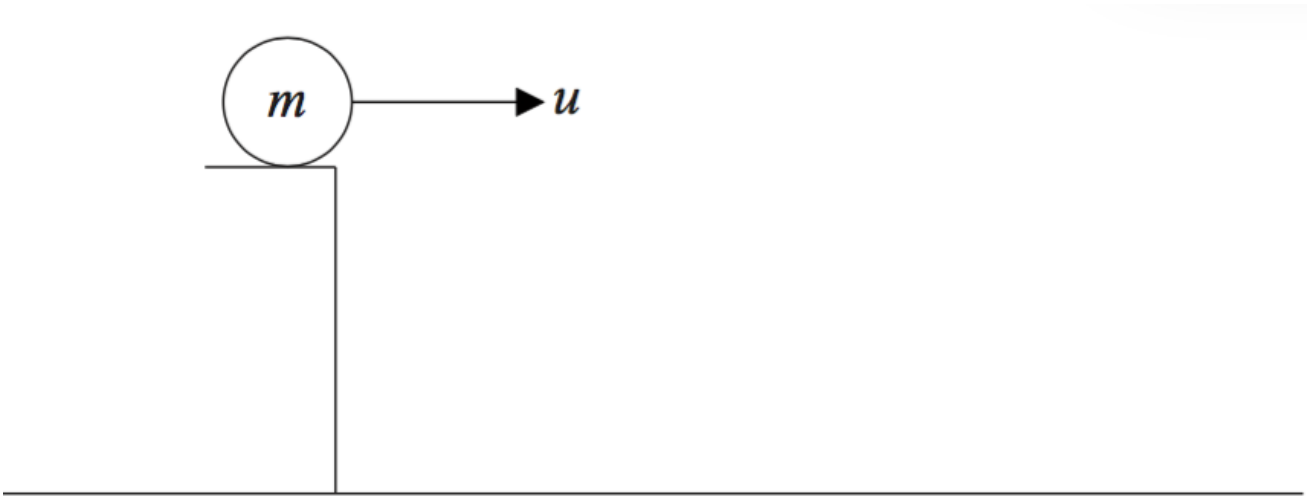
57. Two identical balls are dropped from a tall building, one a few seconds after the other. Air resistance is **not** negligible. As the balls fall, the distance between the balls will *[1 mark]*

A. decrease.
B. increase.
C. increase then remain constant.
D. remain constant.

58. Which of the following is always true for an object moving in a straight line at constant speed? *[1 mark]*

A. No forces act on the object.
B. No resultant force acts on the object.
C. The momentum of the object is zero.
D. No work is being done on the object.

59. A ball of mass m is thrown horizontally from a cliff with initial velocity u. Air resistance is negligible. *[1 mark]*



A change in which of the following will affect the horizontal distance travelled?

A. m only
B. u only
C. both m and u
D. neither m nor u

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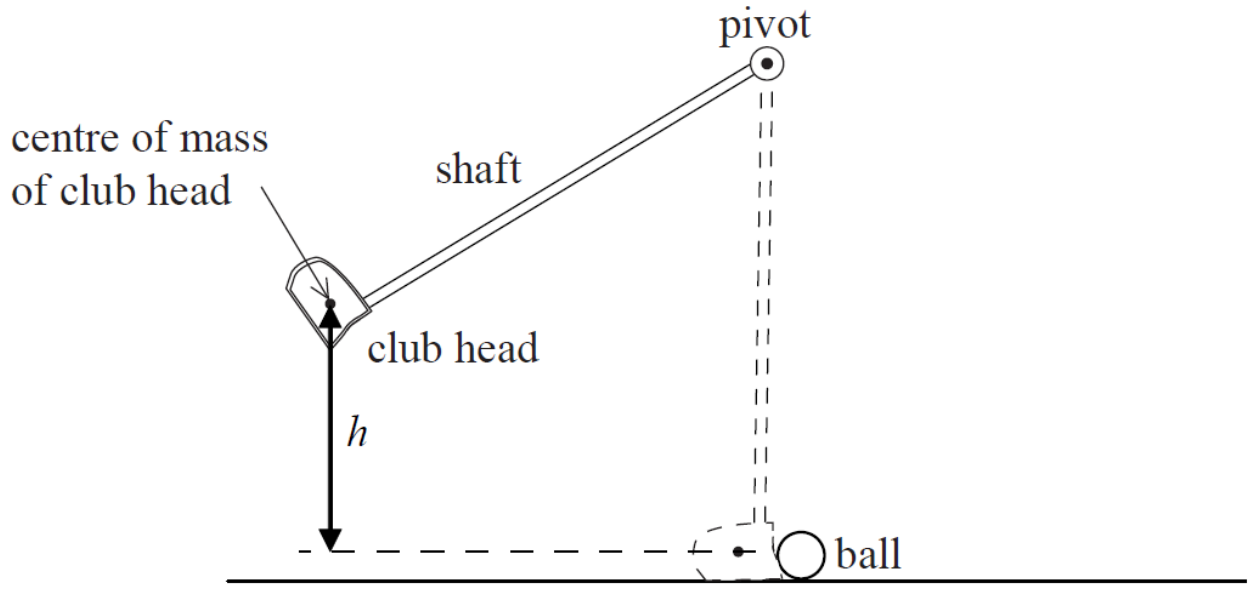
Impulse and momentum

The diagram shows an arrangement used to test golf club heads.



The shaft of a club is pivoted and the centre of mass of the club head is raised by a height h before being released. On reaching the vertical position the club head strikes the ball.

60a. (i) Describe the energy changes that take place in the club head from the instant the club is released until the club head and the ball separate. *[4 marks]*

(ii) Calculate the maximum speed of the club head achievable when h = 0.85 m.

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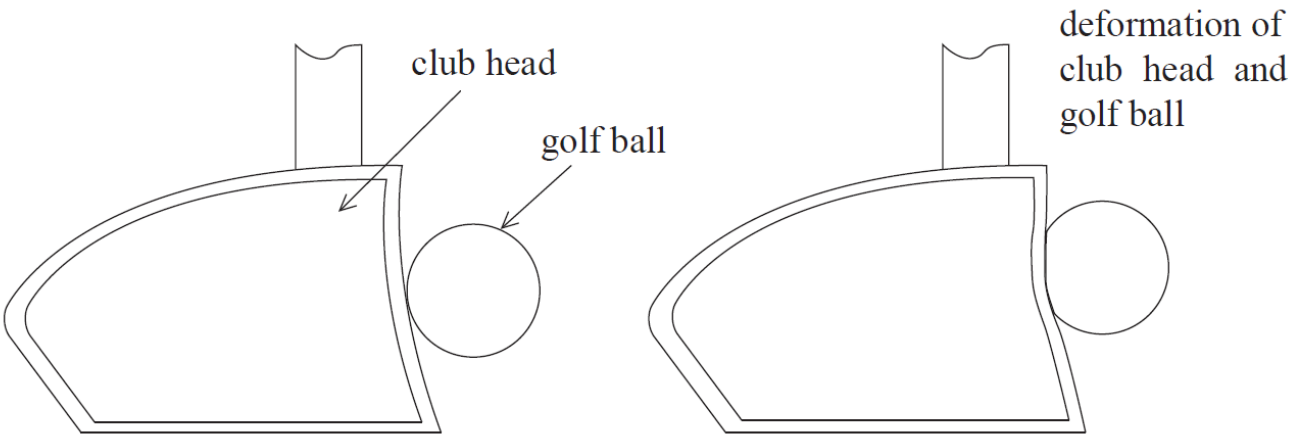
60b. The diagram shows the deformation of a golf ball and club head as they collide during a test. *[2 marks]*



Explain how increasing the deformation of the club head may be expected to increase the speed at which the ball leaves the club.

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60c. In a different experimental arrangement, the club head is in contact with the ball for a time of 220 μs. The club head has mass 0.17 kg and the ball has mass 0.045 kg. At the moment of contact the ball is at rest and the club head is moving with a speed of 38 ms^{-1}. The ball moves off with an initial speed of 63 ms^{-1}. *[5 marks]*

(i) Calculate the average force acting on the ball while the club head is in contact with the ball.

(ii) State the average force acting on the club head while it is in contact with the ball.

(iii) Calculate the speed of the club head at the instant that it loses contact with the ball.

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61a. Define *electric field strength*. *[2 marks]*

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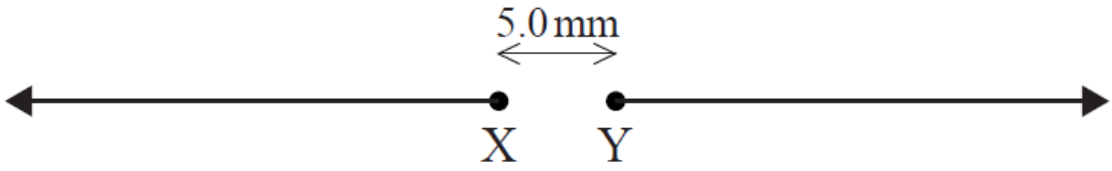
61c. The diagram shows two isolated electrons, X and Y, initially at rest in a vacuum. The initial separation of the electrons is 5.0 mm. The electrons subsequently move apart in the directions shown. *[8 marks]*

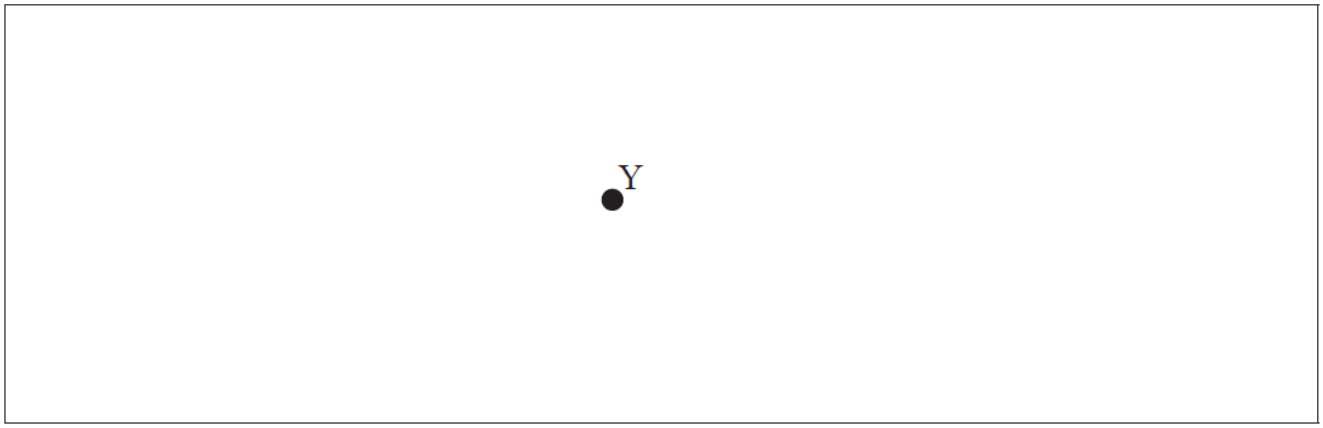


(i) Show that the initial electric force acting on each electron due to the other electron is approximately 9×10^{-24}N.

(ii) Calculate the initial acceleration of one electron due to the force in (c)(i).

(iii) Discuss the motion of one electron after it begins to move.

(iv) The diagram shows Y as seen from X, at one instant. Y is moving into the plane of the paper. For this instant, draw on the diagram the shape and direction of the magnetic field produced by Y.



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This question is about kinematics.

62a. Fiona drops a stone from rest vertically down a water well. She hears the splash of the stone striking the water 1.6 s after the stone leaves her hand. Estimate the *[3 marks]*

(i) distance between Fiona's hand and the water surface.

(ii) speed with which the stone hits the water.

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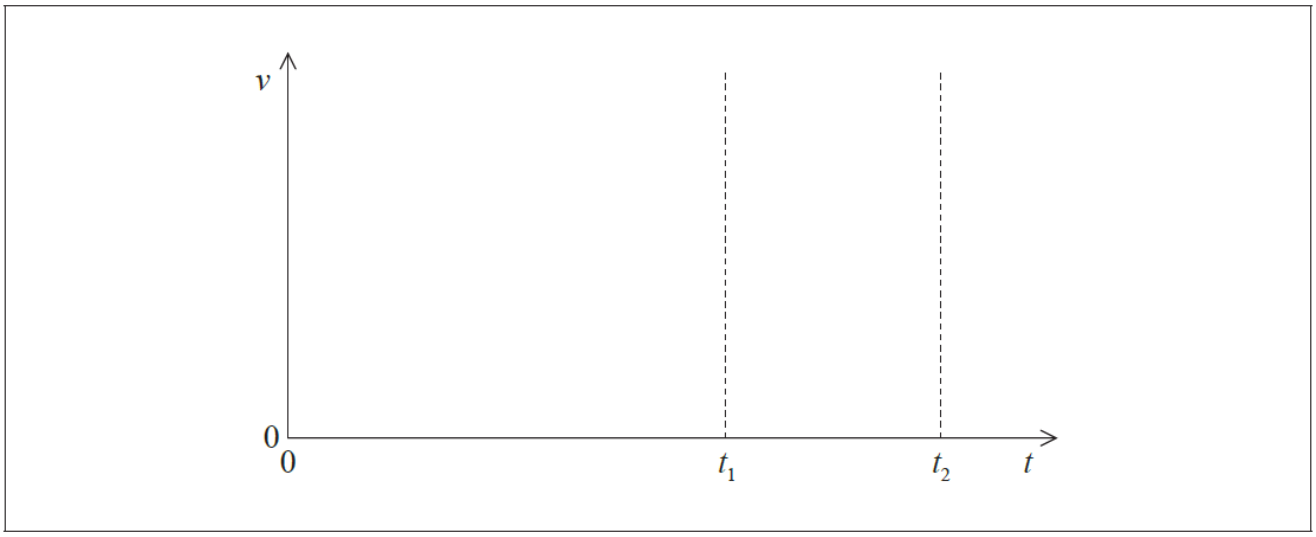
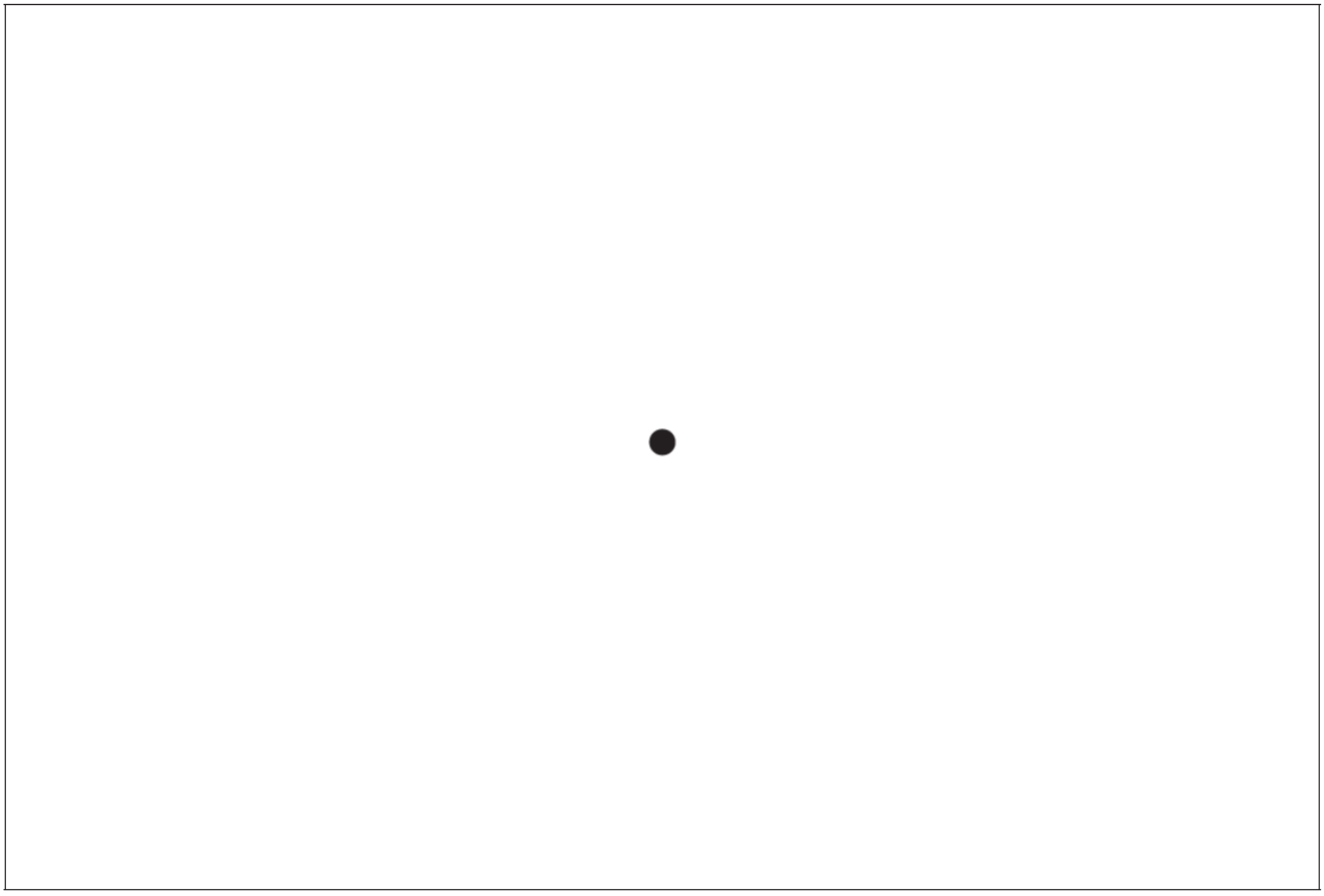
62b. After the stone in (a) hits the water surface it rapidly reaches a terminal speed as it falls through the water. The stone leaves Fiona's hand at time $t = 0$. It hits the water surface at t_1 and it comes to rest at the bottom of the water at t_2. *[3 marks]*
Using the axes below, sketch a graph to show how the speed v of the stone varies from time $t = 0$ to just before $t = t_2$.
(There is no need to add any values to the axes.)



62c. Draw and label a free-body diagram representing the forces acting on the stone as it falls through the water at its terminal speed. *[2 marks]*



Part 2 Momentum

63a. State the law of conservation of momentum. *[2 marks]*

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63b. Far from any massive object, a space rocket is moving with constant velocity. The engines of the space rocket are turned on and it accelerates by burning fuel and ejecting gases. Discuss how the law of conservation of momentum relates to this situation. *[3 marks]*

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63c. Jane and Joe are two ice skaters initially at rest on a horizontal skating rink. They are facing each other and Jane is holding a ball. Jane throws the ball to Joe who catches it. The speed at which the ball leaves Jane, measured relative to the ground, is 8.0 m s^{-1}. *[4 marks]*

The following data are available.

Mass of Jane = 52 kg
Mass of Joe = 74 kg
Mass of ball = 1.3 kg

Use the data to calculate the

(i) speed *v* of Jane relative to the ground immediately after she throws the ball.

(ii) speed *V* of Joe relative to the ground immediately after he catches the ball.

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64. An object, initially at rest, travels a distance *d* in a time *t* at a constant acceleration. What is the time taken for the object to travel 16*d* from rest at the same acceleration? *[1 mark]*

A. 16*t*

B. 8*t*

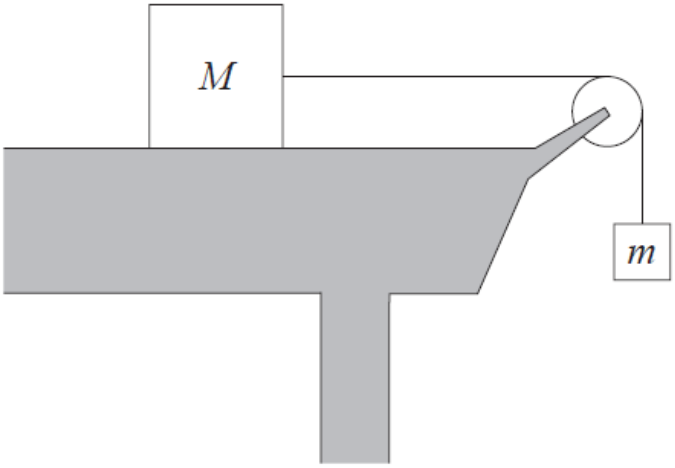
C. 4*t*

D. 2*t*

65. An object is released above the surface of Earth. Which of the following correctly describes the speed and acceleration before it reaches terminal speed? *[1 mark]*

	Speed	Acceleration
A.	increases	remains constant
B.	increases	decreases
C.	remains constant	remains constant
D.	remains constant	decreases

66. An object of mass m is connected via a frictionless pulley to an object of mass M, where $M > m$. M rests on a horizontal frictionless surface *[1 mark]*



What is the acceleration of the system?

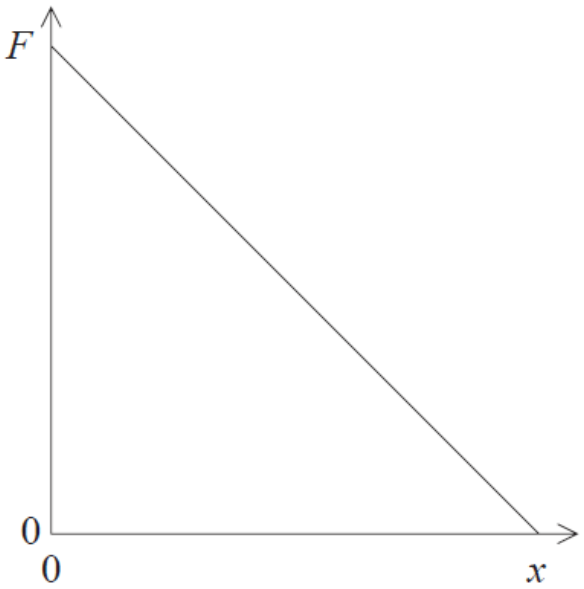
A. $\dfrac{mg}{(M+m)}$

B. $\dfrac{(M+m)g}{m}$

C. $\dfrac{gm}{M}$

D. Zero

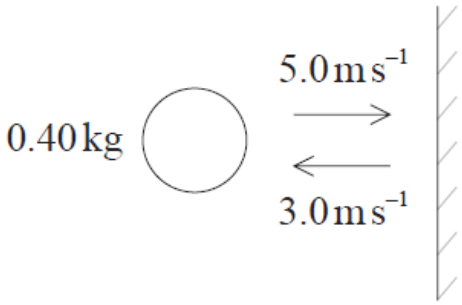
67. The graph shows the variation with distance x of the magnitude of the net force F acting on a body initially at rest. *[1 mark]*



Which of the following describes how the kinetic energy and the acceleration of the body change with distance?

	Kinetic energy	Acceleration
A.	decrease	decrease
B.	decrease	increase
C.	increase	decrease
D.	increase	increase

68. A ball of mass 0.40 kg travels horizontally and strikes a vertical wall with a speed of 5.0 ms^{-1}. It rebounds horizontally with a speed of 3.0 ms^{-1}. The ball is in contact with the wall for a time of 0.20 s. *[1 mark]*



What is the average magnitude of the force exerted by the ball on the wall?

A. 0.16 N
B. 0.64 N
C. 4 N
D. 16 N

69. Which of the following is necessary for an object to be in translational equilibrium? *[1 mark]*

A. The object must be stationary.
B. The object must move with a constant speed.
C. The resultant force acting on the object must be zero.
D. No forces must act on the object.

70. An object is thrown horizontally from the edge of a high crater on the Moon. The Moon has no atmosphere. Which of the following describes the changes, if any, to the horizontal and vertical components of the velocity of the object? *[1 mark]*

	Horizontal velocity	Vertical velocity
A.	stays constant	increases at a constant rate
B.	decreases	increases at a constant rate
C.	stays constant	increases at a non-constant rate
D.	decreases	increases at a non-constant rate

This question is in **two** parts. **Part 1** is about momentum change. **Part 2** is about an oscillating water column (OWC) energy converter.

Part 1 Momentum change

71a. State the law of conservation of linear momentum. *[2 marks]*

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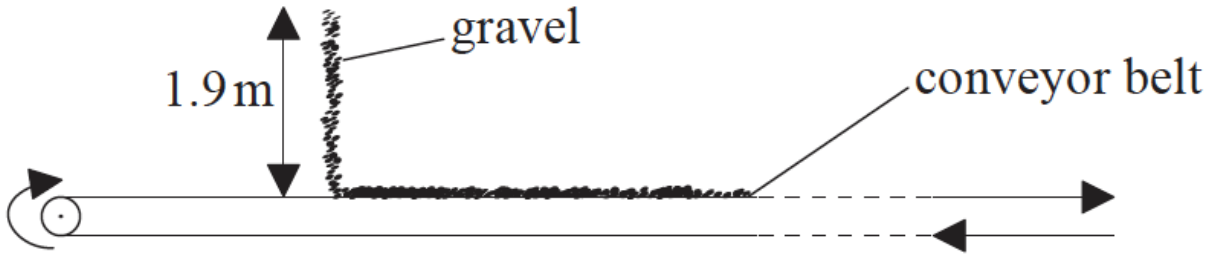
71b. Gravel falls vertically onto a moving horizontal conveyor belt. *[7 marks]*



(i) The gravel falls at a constant rate of 13 kg s^{-1} through a height of 1.9 m. Show that the vertical speed of the gravel as it lands on the conveyor belt is about 6 m s^{-1}.

(ii) The gravel lands on the conveyor belt without rebounding. Calculate the rate of change of the vertical momentum of the gravel.

(iii) Gravel first reaches the belt at $t = 0.0$ s and continues to fall. Determine the total vertical force that the gravel exerts on the conveyor belt at $t = 5.0$ s.

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71c. The conveyor belt moves with a constant horizontal speed of 1.5 m s^{-1}. As the gravel lands on the belt, it has no horizontal speed. *[4 marks]*

(i) Calculate the rate of change of the kinetic energy of the gravel due to its change in horizontal speed.

(ii) Determine the power required to move the conveyor belt at constant speed.

(iii) Outline why the answers to (c)(i) and (ii) are different.

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