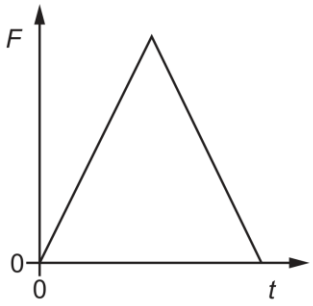
3. Dynamics

3.1 Momentum and Newton's laws of motion

Paper 1

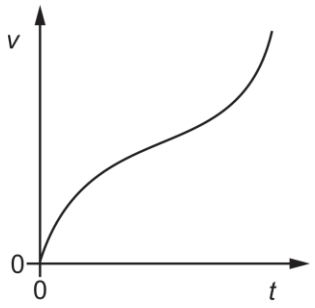
Question Paper

1 A golf club hits a golf ball. The graph shows how the force *F* on the ball varies with time *t*.

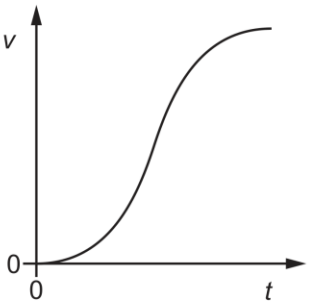


Which graph shows how the velocity *v* of the ball varies with time *t*?

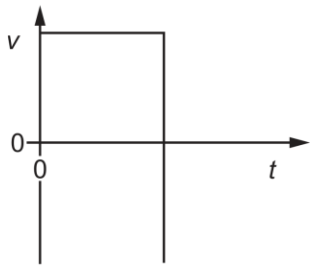
A



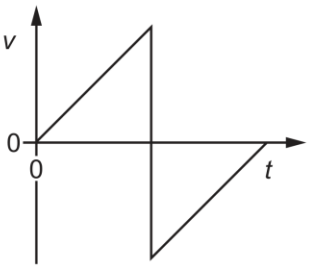
B



C



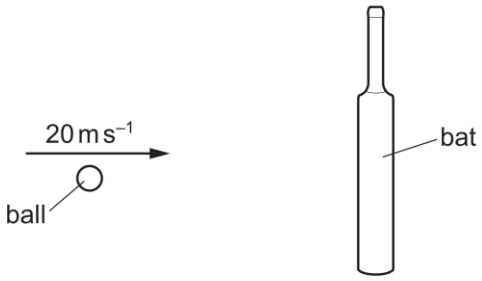
D



2 What is meant by the mass and by the weight of an object on the Earth?

	mass	weight
A	its momentum divided by its velocity	the work done in lifting it one metre
B	the gravitational force on it	the property that resists its acceleration
C	the pull of the Earth on it	its mass divided by the acceleration of free fall
D	the property that resists its acceleration	the pull of the Earth on it

3 A ball of mass 0.10 kg is thrown towards a stationary vertical bat. The ball hits the bat with a horizontal velocity of 20 m s^{-1}.

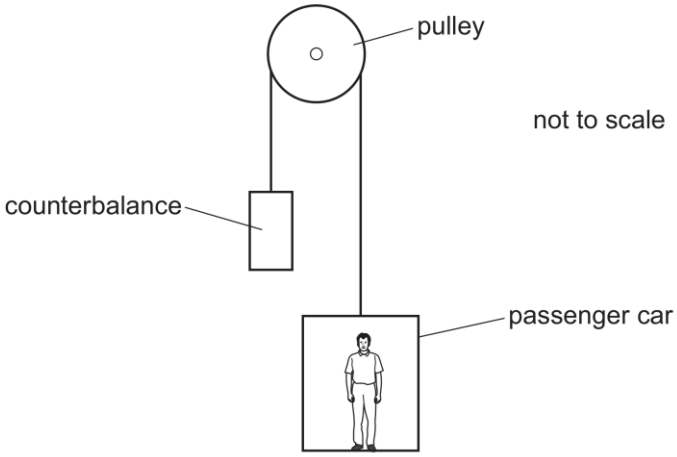


The ball rebounds and leaves the bat with a horizontal velocity of 15 m s^{-1}.

What is the change in momentum of the ball?

A 0.20 N s **B** 0.50 N s **C** 1.5 N s **D** 3.5 N s

4 A lift (elevator) consists of a passenger car supported by a cable that runs over a light, frictionless pulley to a counterbalance. The counterbalance falls as the passenger car rises.



Some masses are shown in the table.

	mass / kg
passenger car	520
counterbalance	640
passenger	80

What is the magnitude of the acceleration of the car when carrying just one passenger and when the pulley is free to rotate?

A $0.032\,\text{m s}^{-2}$ **B** $0.32\,\text{m s}^{-2}$ **C** $0.61\,\text{m s}^{-2}$ **D** $0.65\,\text{m s}^{-2}$

5 A stationary ball of mass m is hit by a bat. The ball leaves the bat with velocity v.

The bat is in contact with the ball for a short time Δt.

What is the average force of the bat on the ball?

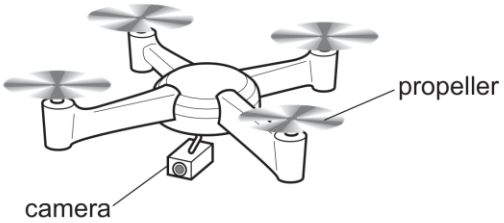
A $mv\Delta t$ **B** $\frac{mv}{\Delta t}$ **C** $\frac{1}{2}mv^2\Delta t$ **D** $\frac{\frac{1}{2}mv^2}{\Delta t}$

6 A ball of mass 2.0 kg travels horizontally with a speed of $4.0\,\text{m s}^{-1}$. The ball collides with a wall and rebounds in the opposite direction with a speed of $2.8\,\text{m s}^{-1}$. The time of the collision is 150 ms.

What is the average force exerted on the wall?

A 16 N **B** 37 N **C** 53 N **D** 91 N

7 A camera drone of mass 1.20 kg hovers at a fixed point above the ground. The drone has four propellers.



In a time of 1.00 s, each propeller pushes a mass of 0.400 kg of air vertically downwards.

Assume that the air above the propellers is stationary.

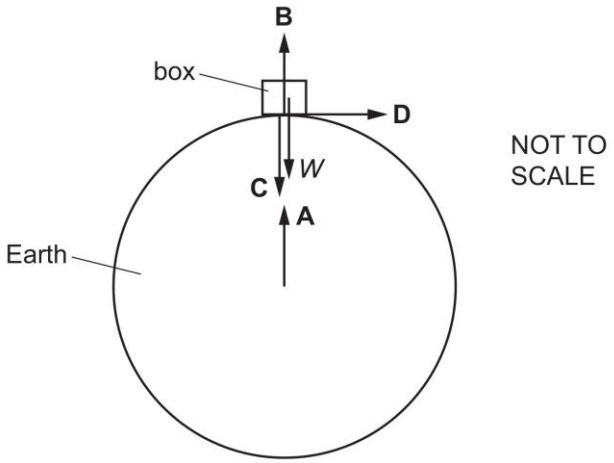
What is the speed of the air leaving each propeller?

A $0.750\,m\,s^{-1}$ **B** $3.00\,m\,s^{-1}$ **C** $7.36\,m\,s^{-1}$ **D** $29.4\,m\,s^{-1}$

8 A box rests on the Earth, as shown.

Newton's third law describes how forces of the same type act in pairs. One of the forces of a pair is the weight *W* of the box.

Which arrow represents the other force of this pair?



9 Which statement describes the mass of an object?

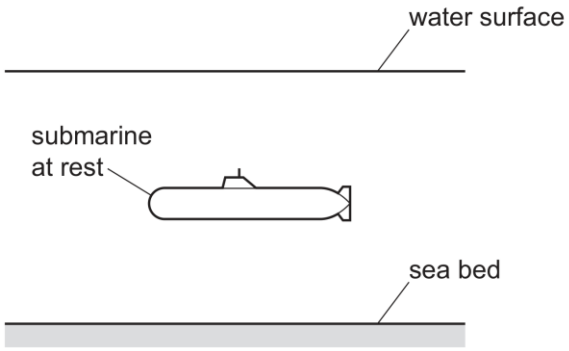
A the force the object experiences due to gravity

B the momentum of the object before a collision

C the resistance of the object to changes in motion

D the weight of the object as measured by a balance

10 A submarine of total mass 3200 kg is at rest underwater.



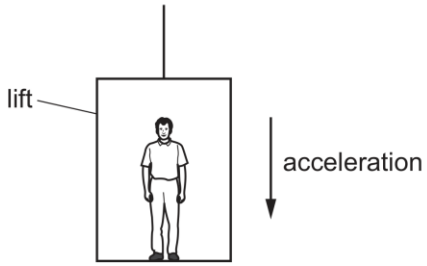
The total mass of the submarine is suddenly decreased by 200 kg by pumping water out of the submarine horizontally in a negligible time. The upthrust acting on the submarine is unchanged.

The change in the total weight of the submarine causes it to accelerate vertically upwards.

What is the initial upwards acceleration of the submarine?

A $0.613\,m\,s^{-2}$ **B** $0.654\,m\,s^{-2}$ **C** $9.81\,m\,s^{-2}$ **D** $10.5\,m\,s^{-2}$

11 A man stands in a lift that is accelerating vertically downwards, as shown.



Which statement describes the force exerted by the man on the floor?

A It is equal to the weight of the man.

B It is greater than the force exerted by the floor on the man.

C It is less than the force exerted by the floor on the man.

D It is less than the weight of the man.

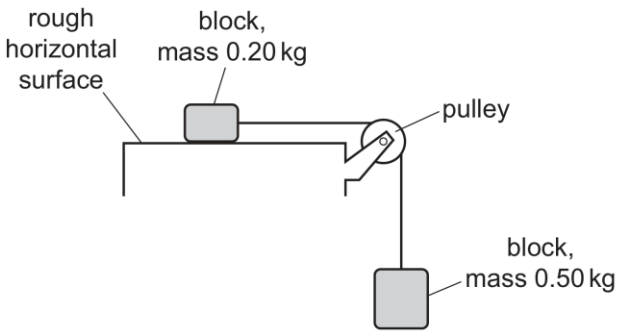
12 A ball of mass 200 g is thrown horizontally with a speed of 20 m s^{-1} against a vertical wall.

The ball is in contact with the wall for a time of 0.10 s before rebounding back along its original path with a speed of 10 m s^{-1}.

What is the average force exerted by the wall on the ball during the collision?

A 20 N **B** 60 N **C** 20 kN **D** 60 kN

13 Two blocks, of mass 0.20 kg and 0.50 kg, are connected by a light inextensible string that passes over a frictionless pulley.



The blocks are initially held stationary. The block of mass 0.20 kg rests on a rough horizontal surface.

The block of mass 0.50 kg is suspended in air. Air resistance is negligible.

When the blocks are released, they have an acceleration of magnitude 2.0 m s^{-2}.

What is the magnitude of the frictional force between the block of mass 0.20 kg and the rough surface?

A 3.5 N **B** 3.9 N **C** 4.5 N **D** 6.3 N

14 A resultant force causes an object to accelerate.

What is equal to the resultant force?

A the acceleration of the object per unit mass

B the change in kinetic energy of the object per unit time

C the change in momentum of the object per unit time

D the change in velocity of the object per unit time

15 An object is moving along the ground in a straight line at a constant speed.

Which statement about the resultant force acting on the object is correct?

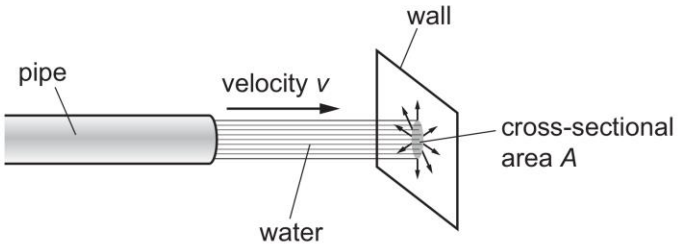
A The resultant force acting on the object is equal to its weight.

B The resultant force acting on the object is equal to the product of its mass and its velocity.

C The resultant force acting on the object is equal to the resistive force.

D The resultant force acting on the object is equal to zero.

16 Water flows out of a pipe and hits a wall.



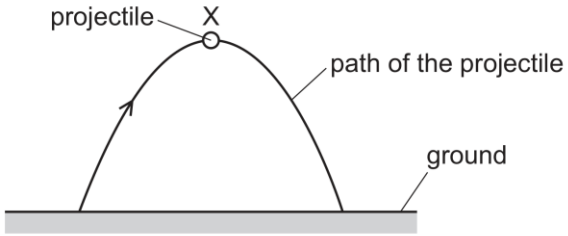
When the jet of water hits the wall, it has horizontal velocity v and cross-sectional area A.

The density of the water is ρ. The water does not rebound from the wall.

What is the force exerted on the wall by the water?

A $\frac{\rho v}{A}$ **B** $\frac{\rho v^2}{A}$ **C** $\rho A v$ **D** $\rho A v^2$

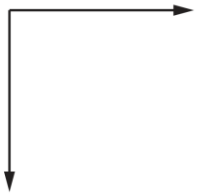
17 A projectile is launched at an angle above horizontal ground and travels through the air.



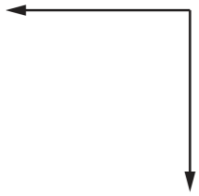
The projectile reaches its maximum height at position X. Assume that no upthrust acts on the projectile.

Which diagram shows the **directions** of the force or forces acting on the projectile at position X?

A



B



C

D



18 Which statement is **not** a requirement of a pair of forces that obey Newton's third law of motion?

A The forces act in opposite directions.

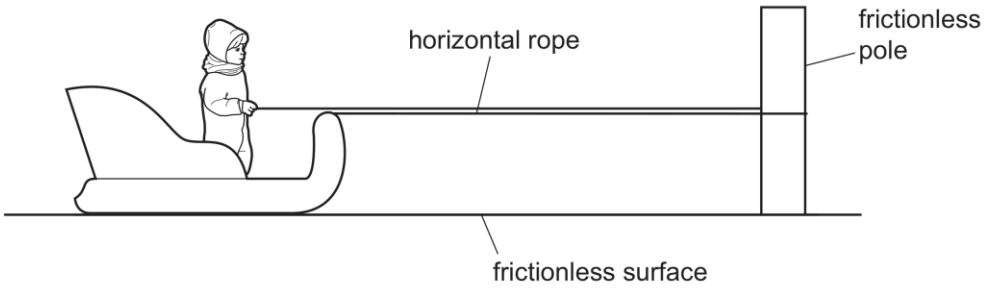
B The forces act on different objects.

C The forces act on objects in contact.

D The forces are of equal magnitude.

19 A child of mass 20 kg stands on the rough surface of a sledge of mass 40 kg. The sledge can slide on a horizontal frictionless surface.

One end of a rope is attached to the sledge. The rope passes around a fixed frictionless pole, and the other end of the rope is held by the child, as shown.



The rope is horizontal. The child pulls on the rope with a horizontal force of 12 N. This causes the child and the sledge to move with equal acceleration towards the pole.

What is the frictional force between the child and the sledge?

A 4.0 N **B** 6.0 N **C** 8.0 N **D** 12 N

20 What is the definition of linear momentum?

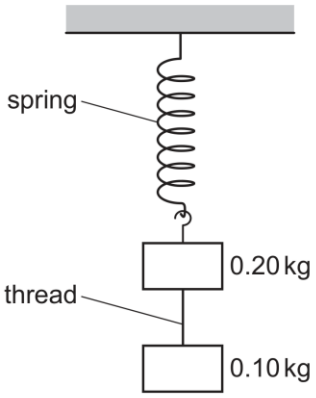
A force per unit time

B product of force and time

C product of velocity and mass

D velocity per unit mass

21 A mass of 0.20 kg is suspended from the lower end of a light spring. A second mass of 0.10 kg is suspended from the first mass by a thread. The arrangement is allowed to come into static equilibrium and then the thread is cut.



Immediately after the thread is cut, what is the upward acceleration of the 0.20 kg mass?

A $4.9\,m\,s^{-2}$ **B** $6.5\,m\,s^{-2}$ **C** $9.8\,m\,s^{-2}$ **D** $15\,m\,s^{-2}$

22 A constant resultant force F acts on an object of mass m for time t.

What is the change in momentum of the object?

A $\frac{F}{t}$ **B** $\frac{Ft}{m}$ **C** Ft **D** $\frac{F}{mt}$

23 The acceleration of free fall on the surface of planet P is one-tenth of that on the surface of planet Q.

On the surface of P, an object has a mass of 1.0 kg and a weight of 1.0 N.

What are the mass and the weight of the same object on the surface of planet Q?

	mass on Q / kg	weight on Q / N
A	1.0	0.1
B	1.0	10
C	10	10
D	10	100

24 A rocket is fired from the Earth into space.

Newton's third law of motion describes how forces act in pairs. One of the forces of a pair is the weight of the rocket.

What is the other force of this pair?

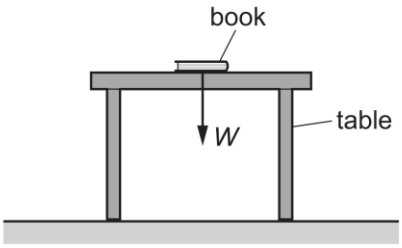
A air resistance

B force of the exhaust gases on the rocket

C force of the rocket on the exhaust gases

D gravitational force of the rocket on the Earth

25 A book of weight *W* is at rest on a table. A student attempts to state Newton's third law of motion by saying that 'action equals reaction'.



If the weight of the book is the 'action' force, what is the 'reaction' force?

A the force *W* acting downwards on the Earth from the table

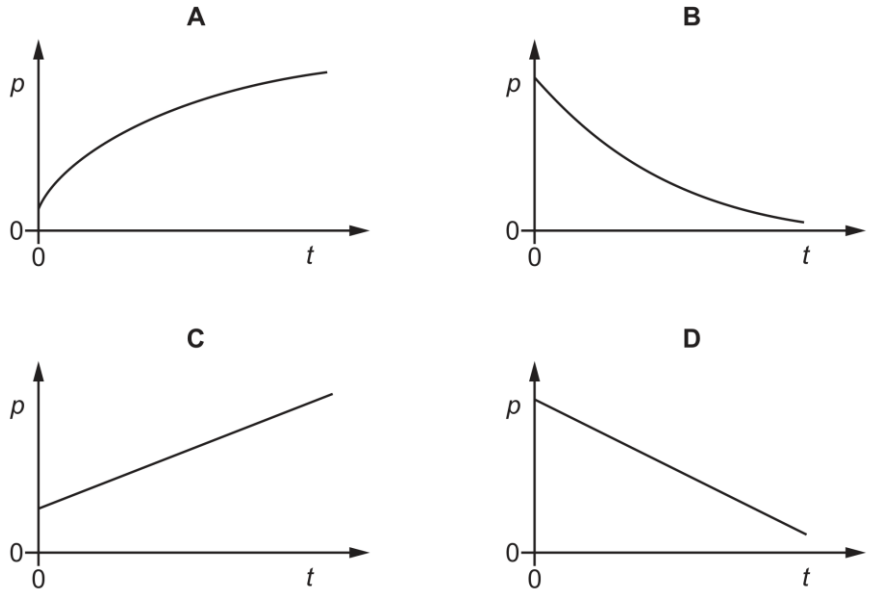
B the force *W* acting upwards on the book from the table

C the force *W* acting upwards on the Earth from the book

D the force *W* acting upwards on the table from the floor

26 A constant resultant force acts on an object in the direction of the object's velocity.

Which graph could show the variation with time t of the momentum p of the object?



27 Which statement **must** be true for an object in a gravitational field?

A If the object has mass then the field causes it to accelerate.

B If the object has mass then the field causes it to have weight.

C If the object has weight then the field causes it to accelerate.

D If the object has weight then the field causes it to have mass.

28 A ball of mass 0.16 kg is travelling horizontally at a speed of 20 m s^{-1}.

It collides with a wall and rebounds with a speed of 15 m s^{-1} along its original path. The ball is in contact with the wall for a time of 1.0 ms.

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

A 800 N **B** 2400 N **C** 3200 N **D** 5600 N

29 What is meant by the mass of an object?

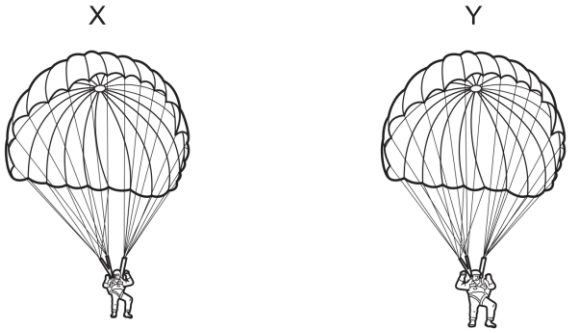
A the property of the object that resists a change in motion

B the pull of the Earth on the object

C the total number of atoms in the object

D the weight of the object

30 The diagram shows two parachutists, X and Y, moving vertically downwards.



The total mass of parachutist Y and his parachute is twice the total mass of parachutist X and his parachute. At this moment, the air resistance on parachute Y is twice the air resistance on parachute X. Neither parachutist has reached his constant (terminal) velocity.

Which statement describes the acceleration of Y compared with the acceleration of X?

A The acceleration of Y is half the acceleration of X.

B The acceleration of Y is the same as the acceleration of X.

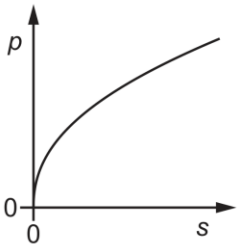
C The acceleration of Y is more than the acceleration of X, but less than twice the value.

D The acceleration of Y is twice the acceleration of X.

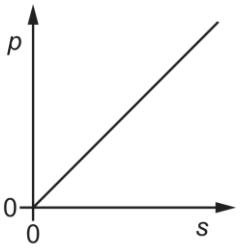
31 A car accelerates from rest in a straight line with constant acceleration.

Which graph best represents the variation of the momentum p of the car with the distance s travelled by the car?

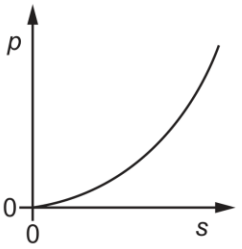
A



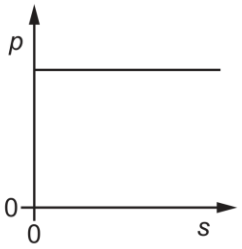
B



C



D



32 A stationary toy gun fires a bullet.

Which statement about the bullet and the gun, immediately after firing, is **not** correct?

A The force exerted on the bullet by the gun has the same magnitude as the force exerted on the gun by the bullet.

B The force exerted on the bullet by the gun is in the opposite direction to the force exerted on the gun by the bullet.

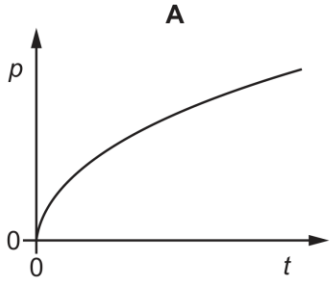
C The gun and the bullet have the same magnitude of momentum.

D The kinetic energy of the gun must equal the kinetic energy of the bullet.

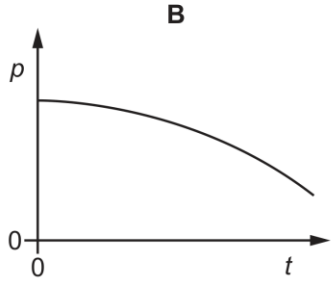
33 The resultant force acting on an object is slowly increased.

Which graph could show the variation with time t of the momentum p of the object?

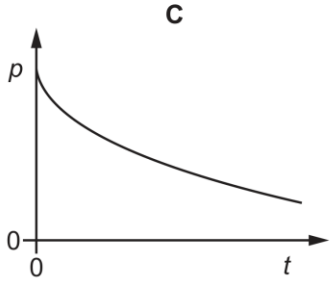
A



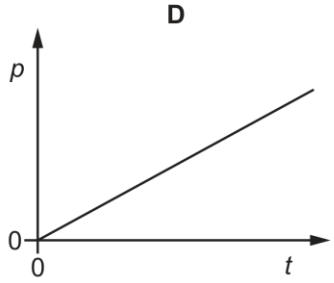
B



C



D



34 An astronaut has a weight of 660 N when she is standing on the Earth's surface.

The acceleration of free fall on the surface of Mars is 3.71 $m\,s^{-2}$.

What would be the weight of the astronaut if she stood on the surface of Mars?

A 67.3 N **B** 178 N **C** 250 N **D** 660 N

35 What is **not** a statement of one of Newton's laws of motion?

A If body X exerts a force on body Y, body Y exerts an equal and opposite force on body X.

B If no resultant force acts on a body it has constant velocity.

C The rate of change of momentum of a body is proportional to the resultant force acting on it and takes place in the direction of the force.

D The total momentum of a system of interacting bodies is constant if there is no external force.

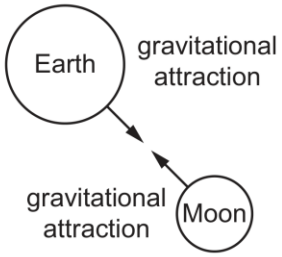
36 Each diagram illustrates a pair of forces of equal magnitude.

Which diagram gives an example of a pair of forces that is described by Newton's third law of motion?

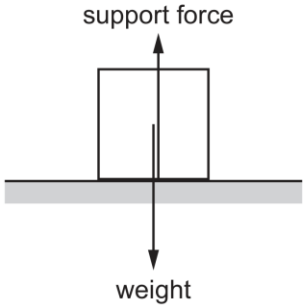
A



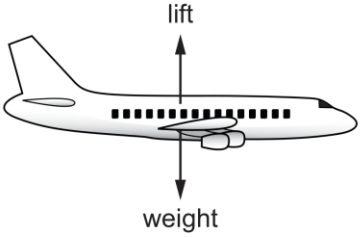
B



C



D



37 A helium atom of mass *m* collides normally with a wall. The atom arrives at the wall with speed *v* and then rebounds along its original path. Assume that the collision is perfectly elastic.

What is the change in the momentum of the atom during its collision?

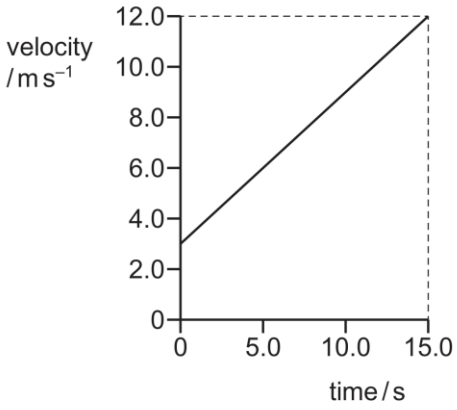
A zero **B** 0.5 *mv* **C** *mv* **D** 2*mv*

38 A car has mass *m*. A person needs to push the car with force *F* in order to give the car acceleration *a*. The person needs to push the car with force 2*F* in order to give the car acceleration 3*a*.

Which expression gives the constant resistive force opposing the motion of the car?

A *ma* **B** 2*ma* **C** 3*ma* **D** 4*ma*

39 The velocity-time graph for an object of mass 2.5 kg is shown.



What is the resultant force acting on the object?

A 0.60 N **B** 0.80 N **C** 1.5 N **D** 2.0 N

40 Which statement follows directly from Newton's first law?

A A body remains at constant velocity unless acted upon by a resultant force.

B A satellite in circular motion about the Earth has a constant velocity.

C A water drop leaving a spinning umbrella travels at a constant velocity.

D The force acting on an object is equal to its change in momentum.

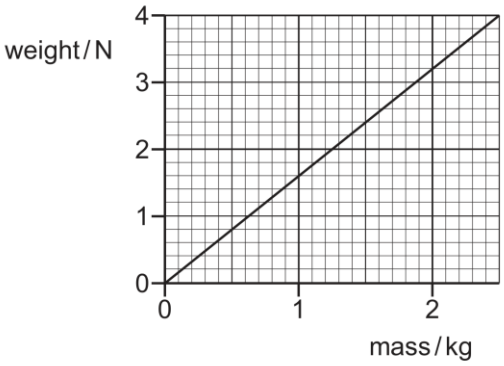
41 A snooker ball has a mass of 200 g. It hits the cushion of a snooker table and rebounds along its original path.

The ball arrives at the cushion with a speed of $14.0\,m\,s^{-1}$ and then leaves it with a speed of $7.0\,m\,s^{-1}$. The ball and the cushion are in contact for a time of 0.60 s.

What is the average force exerted on the ball by the cushion?

A 1.4 N **B** 2.3 N **C** 4.2 N **D** 7.0 N

42 The graph shows the variation with mass of the weight of objects on a particular planet.



What is the value of the acceleration of free fall on the planet?

A $0.63\,m\,s^{-2}$ **B** $1.6\,m\,s^{-2}$ **C** $3.2\,m\,s^{-2}$ **D** $9.8\,m\,s^{-2}$

43 A tennis ball of mass 55 g is travelling horizontally with a speed of $30\,m\,s^{-1}$. The ball makes contact with a wall before rebounding in the horizontal direction with a speed of $20\,m\,s^{-1}$. The ball is in contact with the wall for a time of 5.0×10^{-3} s.

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

A 110 N **B** 220 N **C** 330 N **D** 550 N

44 An astronaut throws a stone horizontally near to the surface of the Moon, where there is no atmosphere.

Which row describes the horizontal and vertical forces acting on the stone after release?

	horizontal force	vertical force
A	non-zero and constant	constant
B	non-zero and constant	decreasing
C	zero	constant
D	zero	decreasing

45 Water is pumped through a hose-pipe at a rate of 90 kg per minute. Water emerges horizontally from the hose-pipe with a speed of $20\,m\,s^{-1}$.

What is the minimum force required from a person holding the hose-pipe to prevent it moving backwards?

A 30 N **B** 270 N **C** 1800 N **D** 108 000 N

46 A ball of mass m is thrown vertically into the air. When the ball has speed v, the air resistance acting on the ball is F.

What is the magnitude of the acceleration of the ball when its speed is v as it rises and as it falls?

	acceleration when ball is rising	acceleration when ball is falling
A	$g - \frac{F}{m}$	$g - \frac{F}{m}$
B	$g - \frac{F}{m}$	$g + \frac{F}{m}$
C	$g + \frac{F}{m}$	$g - \frac{F}{m}$
D	$g + \frac{F}{m}$	$g + \frac{F}{m}$

47 A resultant force of 10 N acts on a body for a time of 2.0 s.

Which graph could show the variation with time t of the momentum p of the body?

