Name ……

Forces & Motion Intervention Booklet

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1 Forces are pushes or pulls.
They are either contact forces (eg friction, air resistance, normal contact force) …
…or non-contact forces (eg gravitational force, magnetic force).

2 Force is a vector quantity.

→ 10 N
← 10 N

These two forces are not the same.
They have the same magnitude, but different directions.

3 The car is moving at a constant velocity because the forces acting on it are balanced.

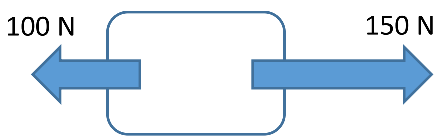
Onto the diagram add arrows to show:

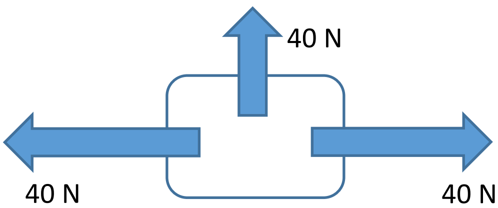
(a) the weight of the car
(b) the normal contact force acting on the car
(c) the thrust acting on the car
(d) the air resistance acting on the car

4 Newton's First Law:
If the resultant force acting on an object is zero and:
- the object is stationary, then the object will remain stationary.
- the object is moving, then the object will continue to move with the same velocity (ie same speed in same direction)

5 HIGHER TIER ONLY
The tendency of objects to continue in a state of rest or constant velocity is called inertia.

Q6 A "resultant force" is the single force that would have the same effect as all the forces acting on a body.



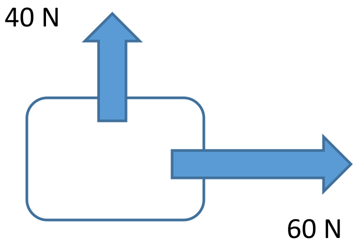


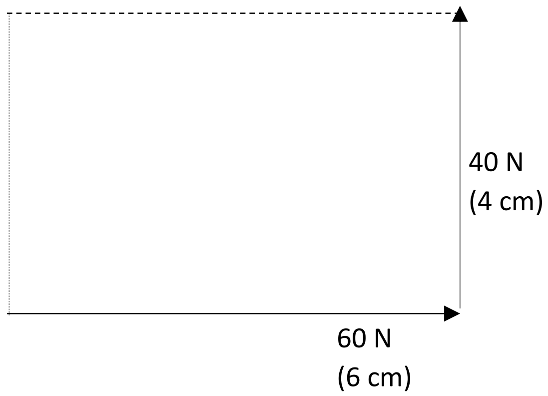
Q6a Resultant force: ……………………..

Q6b Resultant force: …………………………

Q7 HIGHER TIER ONLY

The resultant of two forces that aren't parallel can be found by scale drawing.

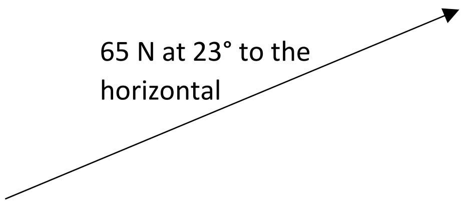




Resultant is ……………………………………………………

Q8 HIGHER TIER ONLY

A force vector can be resolved into two components at right angles to each other.



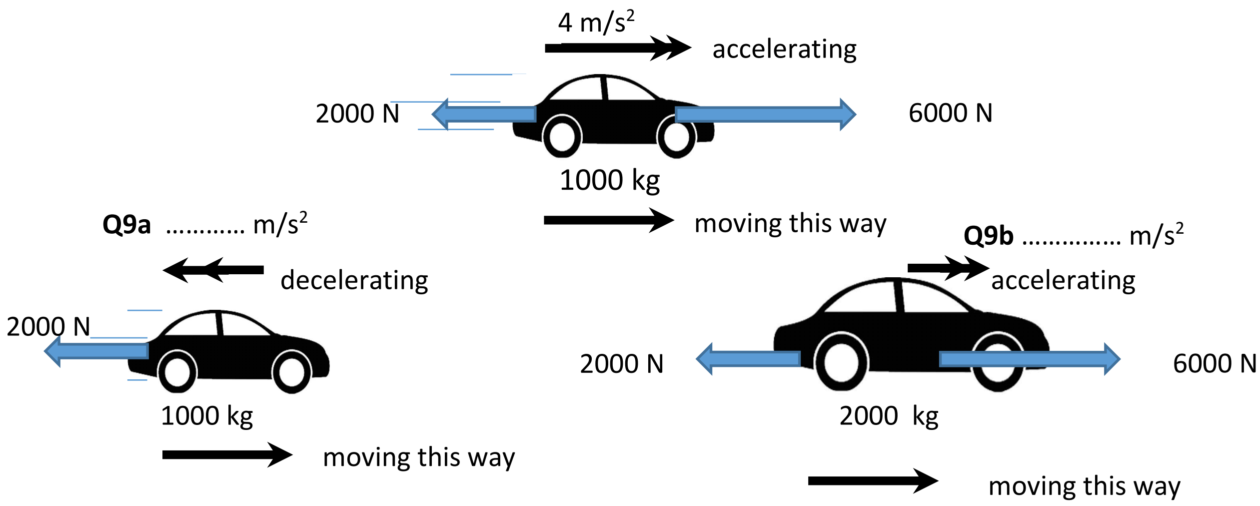
Vertical component is ………………………….

Horizontal component is …………………….

Q9 Newton's 2nd law:

The acceleration of an object is proportional to the resultant force acting on the object, and inversely proportional to the mass of the object.

The object accelerates in the direction of the resultant force.



Q10 $F = m \times a$ F in newton, N m in kilogram, kg a in m/s^2

A car of mass 1 200 kg has 500 N of resistive forces (drag and friction) acting against it.
The car is accelerating at 3 m/s^2.
Calculate the forward force acting on the car.

11 HIGHER TIER ONLY
Inertial mass is a measure of how difficult it is to change the velocity of an object.

Inertial mass is the ratio of force over acceleration. ($a = \frac{F}{m}$)

12 Weight is the force that gravity exerts on a mass.
On the Earth's surface the gravitational field strength is 9.8 N/kg.
Weight = mass × gravitational field strength.

13 Objects behave as if all their mass is concentrated at a single point.
That point is called the centre of mass.

14 Terminal velocity
Objects falling through fluid accelerate while their weight is greater than the drag force acting on them.
As they accelerate the drag force acting on them increases.
When the drag force is the same magnitude as the weight, then the forces balance, the resultant force acting on the object is zero, so the object falls at a constant speed.

Q15 The parachutist opposite is falling at her terminal velocity.

Q15a When she opens her parachute, she decelerates.
Explain, in terms of Newton's 2^{nd} law. why she decelerates when she opens her parachute.

………

………

………

………

Q15b Once her parachute is open, she begins to decelerate.
She does not decelerate for long though. Eventually she stops decelerating and falls at a constant velocity.

Explain, in terms of Newton's 2^{nd} law, why she reaches a constant velocity.

………

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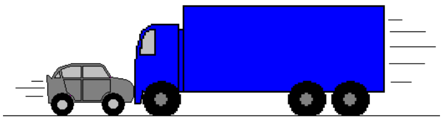
16 Newton's 3rd Law

"Every action has an equal and opposite reaction", ie when one object exerts a force on a second object, the second object exerts a force on the first object that is equal in magnitude but opposite in direction.



The force that the Sun puts on the Earth is equal and opposite to the force that Earth puts on the Sun

The force that the car exerts on the lorry is equal and opposite to the force that the lorry exerts on the car.

Q17 Add force vector arrows to the diagrams in point 16 above to show the equal and opposite forces acting.

18 When a car brakes in emergency its overall stopping distance can be split into the "thinking distance" (the distance the car moves while the driver reacts) and the "braking distance" (the distance the car moves with the brakes applied).

Thinking distance is increased by
- greater speed
- drinking alcohol / taking drugs
- distraction eg using mobile phone
- tiredness increasing reaction time

Braking distance is increased by
- poor road surface
- poor tyre condition
- poor brake condition
- wet surface / brakes / tyres

19 HIGHER TIER ONLY

momentum = mass × velocity

$p = m v$

momentum is in units of Ns or kgm/s

mass is in units of kg

velocity is in units of m/s

The momentum of a system is conserved (unless acted on by an external force)

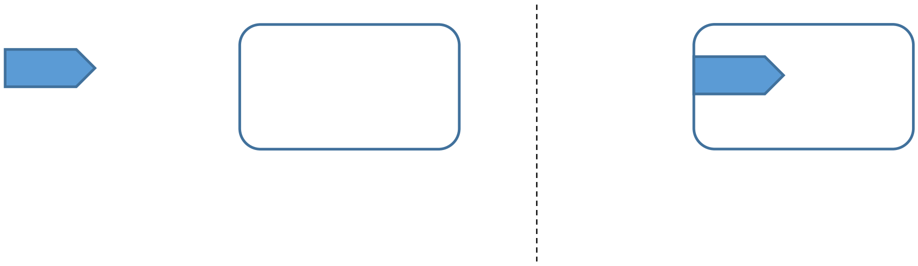
Q20 HIGHER TIER ONLY

A bullet of mass 300 g hits a stationary wooden block of mass 2 kg.

Before the collision the bullet's velocity is 700 m/s.

The bullet lodges in the wooden block.

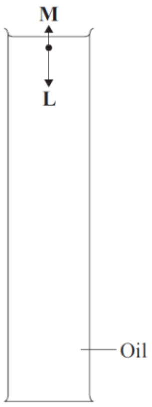
Use the principle of conservation of momentum to calculate how fast the block, with the bullet within it, moves after the impact.



GCSE Style Practice Questions

Q21

(a) The diagram shows a steel ball-bearing falling through a tube of oil.
The forces, **L** and **M**, act on the ball-bearing.

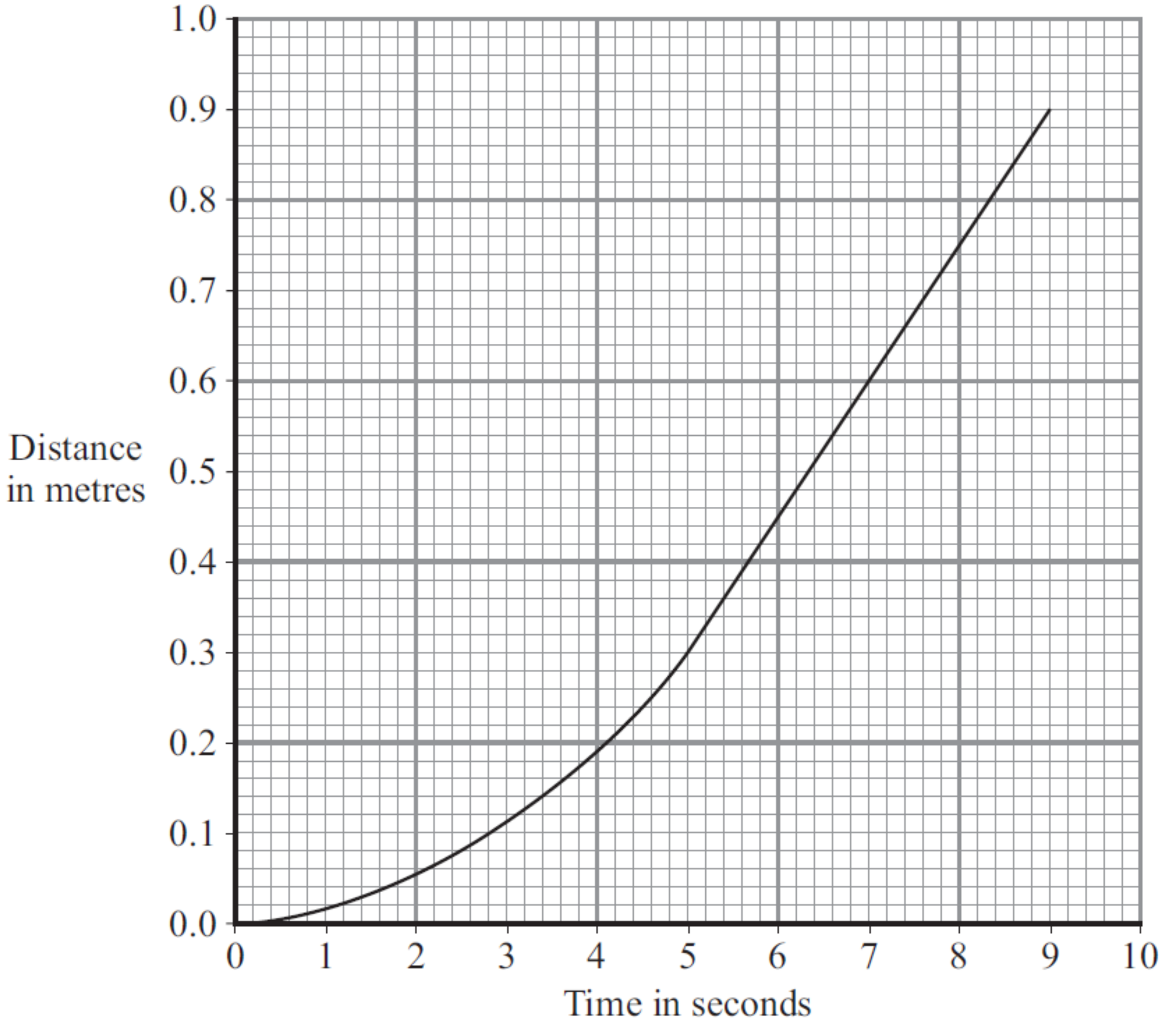


What causes force **L**?

....

(1 mark)

(b) The distance – time graph represents the motion of the ball-bearing as it falls through the oil.



(b) (i) Explain, in terms of the forces, **L** and **M**, why the ball-bearing accelerates at first but then falls at constant speed.

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(3 marks)

(b) (ii) What name is given to the constant speed reached by the falling ball-bearing?

....

(1 mark)

Q22

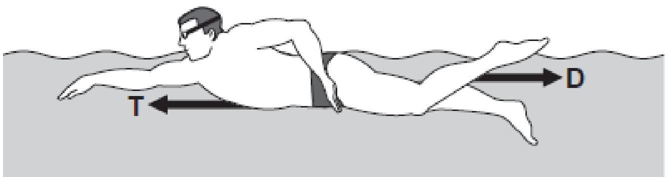
(b) The diagram shows a skier who is accelerating down a steep ski slope.

(b) (i) Draw an arrow on the diagram to show the direction of the resultant force acting on the skier.

(1 mark)

Q23

(a) The diagram shows the horizontal forces acting on a swimmer.



(a) (i) The swimmer is moving at constant speed.
Force **T** is 120 N.

What is the size of force **D**?

.... N

(1 mark)

(a) (ii) By increasing force **T** to 140 N, the swimmer accelerates to a higher speed.

Calculate the size of the initial resultant force acting on the swimmer.

....

....

Initial resultant force = ... N

(1 mark)

(a) (iii) Even though the swimmer keeps the force **T** constant at 140 N, the resultant force on the swimmer decreases to zero.

Explain why.

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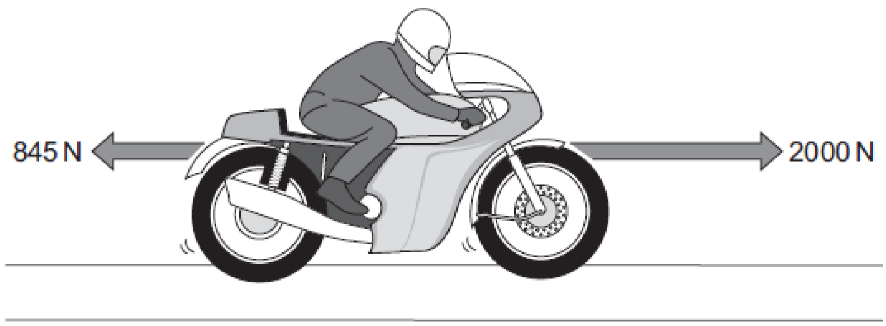
(3 marks)

Q24

The arrows in the diagram represent the horizontal forces acting on a motorbike at one moment in time.

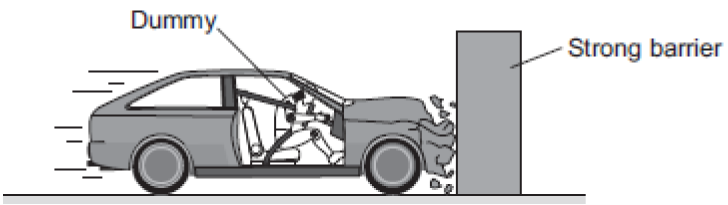


(a) The mass of the motorbike and rider is 275 kg.

Calculate the acceleration of the motor bike at the moment shown.

Q25

The front crumple zone of a car is tested at a road traffic laboratory. This is done by using a remote control device to drive the car into a strong barrier. Electronic sensors are attached to the dummy inside the car.



(i) At the point of collision, the car exerts a force of 5000 N on the barrier.

State the size and direction of the force exerted by the barrier on the car.

....

....

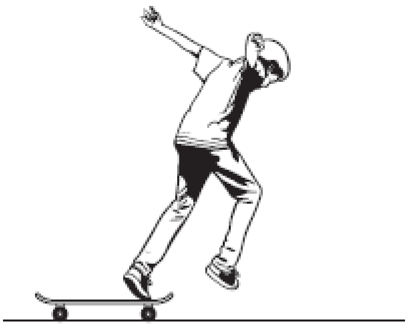
(1 mark)

Q26

Figure 6 shows a skateboarder jumping forwards off his skateboard.

The skateboard is stationary at the moment the skateboarder jumps.

Figure 6



(a) The skateboard moves backwards as the skateboarder jumps forwards.

Explain, using the idea of momentum, why the skateboard moves backwards.

[3 marks]

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....

(b) The mass of the skateboard is 1.8 kg and the mass of the skateboarder is 42 kg.

Calculate the velocity at which the skateboard moves backwards if the skateboarder jumps forwards at a velocity of 0.3 m/s.

Use the correct equation from the Physics Equations Sheet.

[3 marks]

....

....

....

....

....

....

Velocity of skateboard = ... m/s

Forces & Motion Intervention Booklet Worked Answers

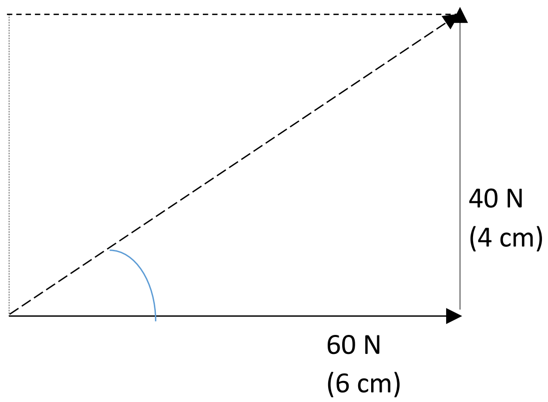
Q6a 150 N – 100 => 50 N to the right.

Q6b Horizontally the forces balance. The resultant of all 3 forces is 40 N upwards.

Q7 The resultant force is the the force vector that has the same affect as that 60 N force added to the 40 N force.

That's the diagonal force vector shown opposite.

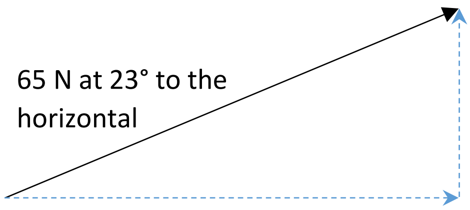
That vector has a length of 7.2 cm on this diagram, which uses a scale of 1 cm to 10 N.



7.2 cm => 72 N. A protractor can be used to measure the angle shown as 37°.

So the resultant force is **72 N at 37°** to the 60 N force.

Q8



Vertical component is ..2.3 cm => **23 N**

Horizontal component is ..6.1cm => **61N**.

Q9a The resultant force is 2000 N, which is half of the 4 000 N resultant force acting on the first car.

As acceleration is ∝ resultant force, is the resultant force is half as big, and the mass of the car is the same, the acceleration will be half as big. ½ × 4 m/s^2 => 2 m/s^2.

As the resultant force is in the opposite direction to the motion, this car will decelerate at 2 m/s^2.

Q9b The resultant force is 4000 N, which is the same as for the first car.

This car's mass is 2000 kg, which is twice the mass of the first car.

As acceleration is inversely proportional to the mass (a ∝ $^1/_m$), the car in 9b, having twice the mass, will have half the acceleration

ie ½ ×4 m/s^2 => 2 m/s^2.

Q10 F = m × a

F = 1200 × 3 = 3600 N so the resultant force on the car is 3 600 N.

If there's a drag force of 500 N on the car …

500 N

? N

… then this force must be 3 600 N bigger than 500 N if the resultant is to be 3 600 N.

Forward force acting on car = 3 600 + 500 = **4 100 N**

Q15a (opening parachute) increases upwards force…

… so upwards force is greater than her weight / downwards force …

so resultant force is (upwards and) in the opposite direction to her velocity …

(… so she decelerates.)

Q15b (As she slows down) the air resistance / drag (acting on her) decreases.

(When the drag has decreased so much that) the drag/air resistance is the same magnitude as her weight / balances her weight..

… then the resultant force acting on her is zero…

(so she will move at a constant velocity).

Q17

Q20 momentum of bullet before collision:

300 g => 0.300 kg $p = m v = 0.3 \text{ kg} \times 700 \text{ m/s}$

$= 210 \text{ Ns}$ (or 210 kg m/s)

momentum of block before collision is zero, so total momentum of block and bullet before collision is 210 Ns.

Momentum is conserved so momentum after the collision is also 210 Ns.

So, for after the collision:

$$p = m \times v$$
$$210 = (2 + 0.3) \times v$$
$$210 = 2.3 \times v$$
$$v = \frac{210}{2.3}$$
$$v = 91.2 \text{ m/s}$$

Q21a Weight / gravitational attraction / gravity

Q21bi The ball accelerates at first because weight (L) is bigger than drag/oil resistance (M)…
… so the resultant force acting on the ball bearing is downwards / in the same direction as the ball bearing's movement.

(The ball reaches a constant speed because as the ball's) speed increases the drag increases. Eventually the drag force has a magnitude equal to the weight, so the resultant force acting on the ball is zero.

Q22bii terminal velocity

Q23ai 120 N (constant speed => the forces must balance)

Q23aii (140 – 120 =) 20 N

Q23aiii As his speed increases …
… the drag force / force D / water resistance increases.
Eventually the drag force will reach 140 N / same magnitude as the forward force

Q24a F = 2000 – 845 = 1155 N

$F = m a$
$1155 = 275 \times a$
$a = \frac{1155}{275} = 4.2 \text{ m/s}^2$

Q25 5 000 N left / opposite direction to the car's velocity

(This is Newton's 3rd law, when the car exerts a force on the wall, the wall exerts an equal magnitude, opposite direction force on the car.)

Q26a Total momentum of skateboarder and skate board before jump is zero.

Momentum is conserved, so the total momentum of the skater and board must be zero after the jump.

The boarder has momentum after the jump, so the board must have equal magnitude but opposite direction momentum so that the total momentum of board and boarder is zero.

Q26b Momentum of skateboarder: $p = m\,v = 42\text{ kg} \times 0.3\text{ m/s} = 12.6\text{ Ns}$ (or 12.6 kgm/s)

So momentum of board must be -12.6 Ns.

For board: $p = m\,v$

$-12.6 = 1.8 \times v$

$v = -\dfrac{12.6}{1.8} = (-)\ 7\text{ m/s}$