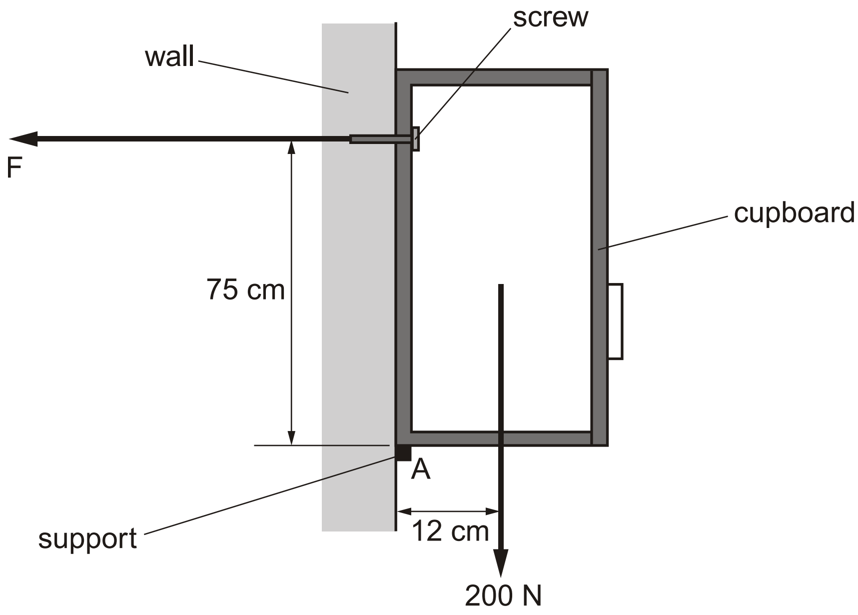
Questions on Forces

1. The figure below shows a kitchen cupboard securely mounted to a vertical wall. The cupboard rests on a support at **A**.



The total weight of the cupboard and its contents is 200 N. The line of action of its weight is at a distance of 12 cm from **A**. The screw securing the cupboard to the wall is at a vertical distance of 75 cm from **A**.

(i) State the principle of moments.

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

....

[2]

(ii) The direction of the force F provided by the screw on the cupboard is horizontal as shown in the figure above. Take moments about **A**. Determine the value of F.

F = ... N

[2]

(iii) The cross-sectional area under the head of the screw in contact with the cupboard is 6.0×10^{-5} m^2. Calculate the pressure on the cupboard under the screw head.

pressure = ...Pa

[2]

(iv) State and explain how your answer to (iii) would change, if at all, if the same screw was secured much closer to **A**.

....

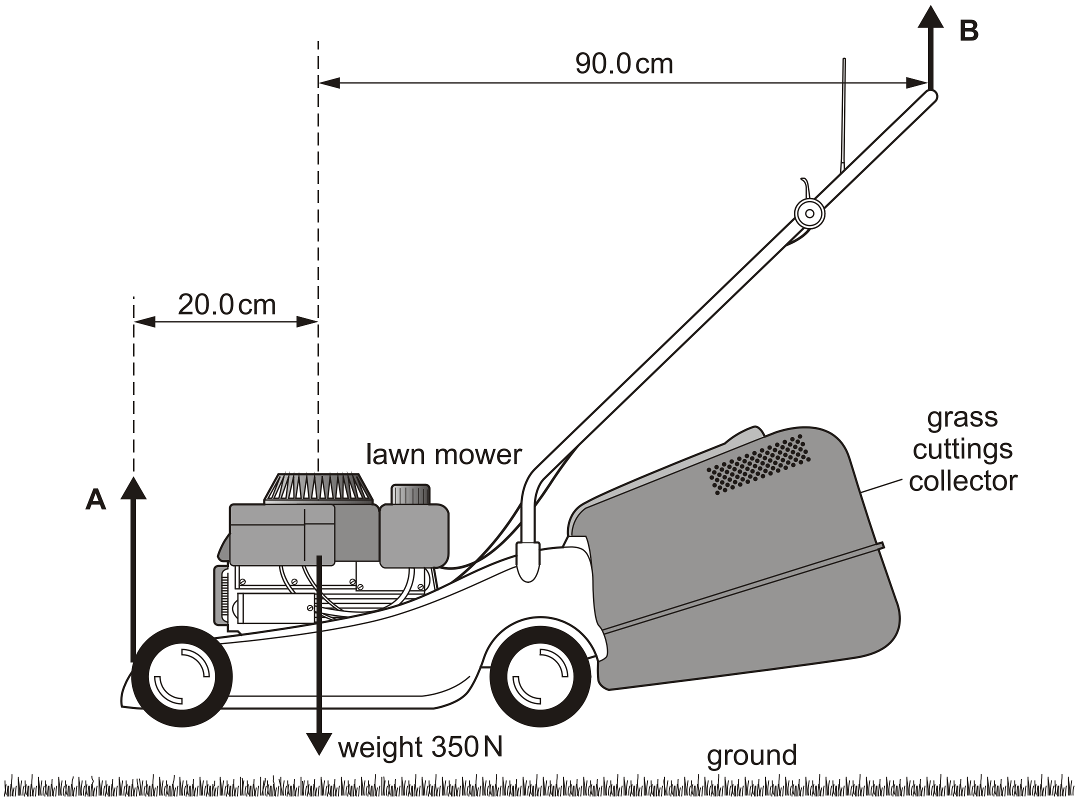
....

....

[2]

[Total 8 marks]

2. The figure below shows a lawn mower which is carried by two people.



(i) The two people apply forces ***A*** and ***B*** at each end of the lawn mower. The weight of the lawn mower is 350 N.

1 Explain why the weight of the lawn mower does not act in the middle of the lawn mower, that is 55 cm from each end.

....

....

[1]

2 Use the principle of moments to show that the force ***B*** is 64 N.

[2]

3 Determine the force ***A***.

A = ...N

[1]

(ii) State and explain what happens to the forces ***A*** and ***B*** if the person that applies force ***B*** moves his hands along the handle towards the middle of the lawn mower.

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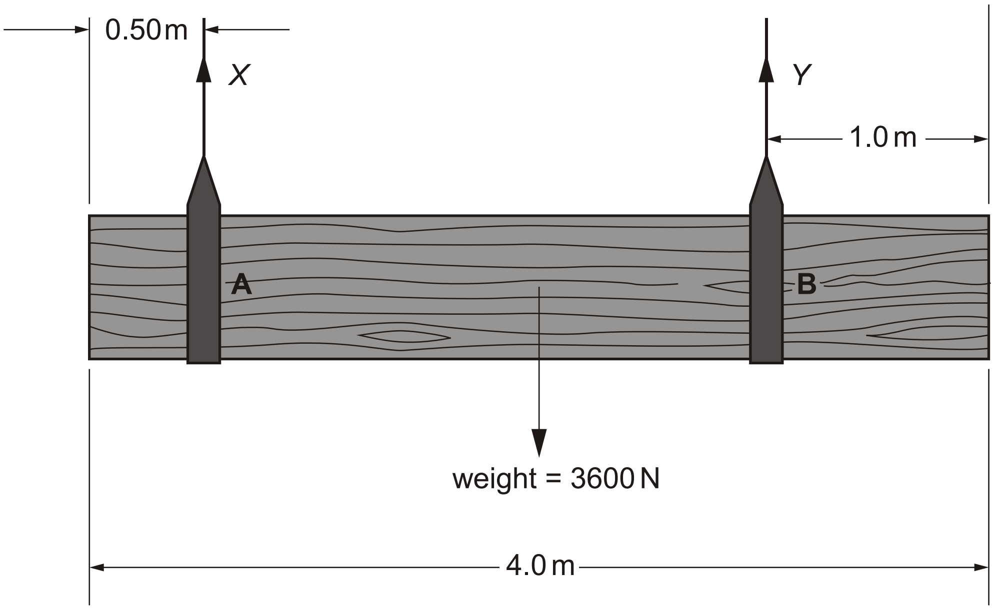
....

....

[2]

[Total 6 marks]

3. The figure below shows a uniform rectangular beam supported by two straps. The beam is in equilibrium.



The weight of the beam is 3600 N and its length is 4.0 m. The strap **A** is positioned 0.50 m from one end of the beam and the strap **B** is positioned 1.0 m from the other end.

(i) **1** Use the principle of moments to show that the upward force X at strap A is 1440 N.

[2]

2 Hence determine the force Y at the strap **B**.

force = ... N

[2]

(ii) Discuss whether the forces X and Y provide a couple.

....

....

....

....

[2]

(iii) The area of strap **A** in contact with the underside of the beam is 2.3×10^{-2} m^2. Calculate the average pressure exerted on the beam by strap **A**.

pressure = ... unit ....

[3]

[Total 9 marks]

4. Define the *newton*.

....

....

[Total 1 mark]

5. A car of mass 1380 kg, travelling at 31.1 m s^{-1}, is brought to rest by the brakes in 48.2 m. Calculate

(i) the initial kinetic energy of the car

kinetic energy = ... J

[3]

(ii) the average deceleration of the car

deceleration = ... m s^{-2}

[2]

(iii) the average braking force.

braking force = ... N

[2]

[Total 7 marks]

6. Describe in terms of the forces acting on the driver how wearing a seat belt and having an airbag in a car can help to protect the driver from injury in a head on collision.

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....

[Total 4 marks]

7. State two factors that affect the braking distance of a car. Describe how each factor affects the braking distance.

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....

[Total 4 marks]

8. Describe how Global Positioning System (GPS) is used to locate the position of a car on the Earth's surface.

✎ *In your answer, you should use appropriate technical terms, spelled correctly.*

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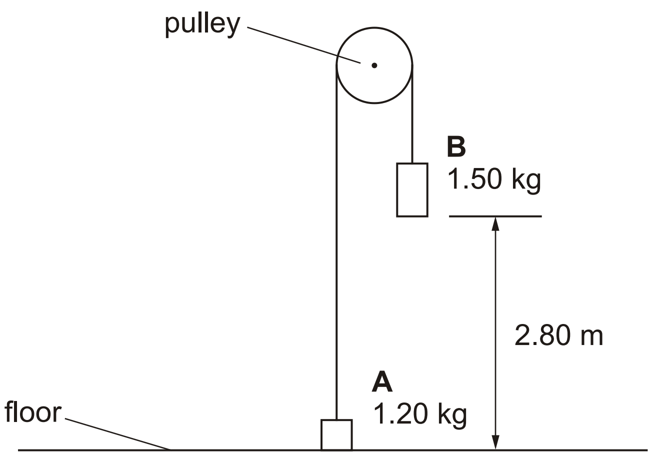
....

[Total 4 marks]

9. The figure below shows two masses **A** and **B** tied to the ends of a length of string. The string passes over a pulley. The mass **A** is held at rest on the floor.



The mass **A** is 1.20 kg and the mass **B** is 1.50 kg.

(a) Calculate the weight of mass **B**.

weight = ... N

[1]

(b) Mass **B** is initially at rest at a height of 2.80 m above the floor. Mass **A** is then released. Mass **B** has a constant downward acceleration of 1.09 m s^{-2}. Assume that air resistance and the friction between the pulley and the string are negligible.

(i) In terms of forces, explain why the acceleration of the mass **B** is less than the acceleration of free fall *g*.

....

....

[1]

(ii) Calculate the time taken for the mass **B** to fall 1.40 m.

time = ... s

[3]

(iii) Calculate the velocity of mass **B** after falling 1.40 m.

velocity = ... m s^{-1}

[2]

(iv) Mass **B** hits the floor at a speed of 2.47 m s^{-1}. It **rebounds** with a speed of 1.50 m s^{-1}. The time of contact with the floor is 3.0×10^{-2} s. Calculate the magnitude of the average acceleration of mass **B** during its impact with the floor.

acceleration = ... m s^{-2}

[2]

[Total 9 marks]

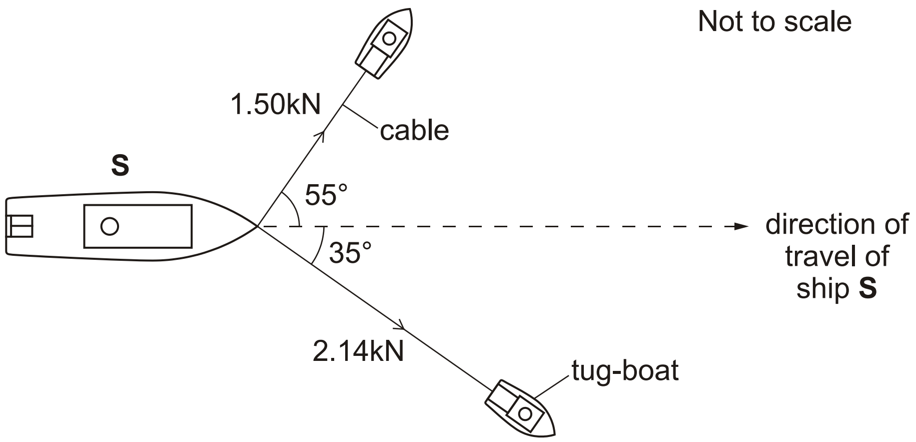
10. State why the equation '$F = ma$' cannot be applied to particles travelling at speeds very close to the speed of light.

....

....

[Total 1 mark]

11. The figure below shows a ship **S** being pulled by two tug-boats.



The ship is travelling at a constant velocity. The tensions in the cables and the angles made by these cables to the direction in which the ship travels are shown in the figure above.

(i) Draw a vector triangle and determine the resultant force provided by the two cables.

resultant force = ... kN

[3]

(ii) State the value of the drag force acting on the ship **S**. Explain your answer.

....

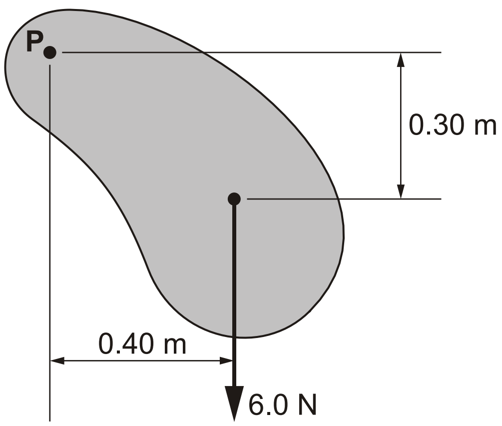
....

....

[2]

[Total 5 marks]

12. Describe an experiment to determine the centre of gravity of the metal plate shown in the figure below.



....

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....

....

[Total 3 marks]

13. The figure below shows the horizontal forces acting on a car of mass 900 kg when it is travelling at a particular velocity on a level road.

The total forward force between the tyres and the road is 200 N and the air resistance (drag) is 80 N.

(i) Calculate the acceleration of the car.

acceleration = ... m s^{-2}

[2]

(ii) Explain why we cannot use the equation $v = u + at$ to predict the velocity of the car at a later time even when the forward force is constant.

....

....

[1]

[Total 3 marks]

Questions on Forces – Mark Scheme

1. (i) Expected answer:
'For equilibrium of an object the sum of clockwise moments about a point = sum of anticlockwise moments about the same point.'

clockwise moment(s) = anticlockwise moment(s)

> ***Note**: The term 'clockwise' to be included and spelled correctly to gain the M1 mark*
> ***Note**: 'net moment = 0' is equivalent to the M1 mark*

M1

Reference to one of the moments taken about a point/'equilibrium'/sum (or total or net or ∑) mentioned once

> ***Note**: If M1 is lost for incorrect spelling of 'clockwise', then allow this A1 mark*

A1

(ii) $200 \times 12 = F \times 75$

C1

$F = 32$ (N)

> ***Note**: Bald answer of 32 (N) scores 2/2 marks*

A1

(iii) $p = \dfrac{32}{6.0 \times 10^{-5}}$

> *Possible ecf*

C1

pressure = 5.3×10^5 (Pa)

> ***Note**: Bald answer of 5.3×10^5 (Pa) scores 2/2 marks*

A1

(iv) (Pressure is) greater

B1

because the force/F is larger (to provide the same moment)

B1

[8]

2.	(i)	**1**	The (distribution of the) mass of the lawn mower is not uniform	B1
		2.	One correct moment about A stated	
			B × 110 or 350 × 20	B1
			B = (350 × 20) / 110 (moments equated)	B1
			B = 63.6 (N)	A0
		3.	A = 350 – 63.6 = 286(.4) (N)	A1
	(ii)		A goes down and B goes up	B1
			Turning effect of B is less / B needs greater force to produce the same moment / if distance goes down force needs to go up (to maintain the same turning effect)	B1

[6]

3.	(i)	1	3600 × 1.0 = X × 2.5	C2
			one mark for one correct moment, one mark for the second correct moment and equated to first moment	A0
		2	X = 1440 (N)	C1
			Y = 3600 – 1440 or 3600 × 1.5 = Y × 2.5	A1
			= 2160 (N)	B1
	(ii)		Not a couple as forces are not equal	B1
			and not in opposite directions / the forces are in the same direction	C1
	(iii)		P = F / A	B1
			= 1440 / 2.3 × 10^{-2}	B1
			= 62609 (6.3×10^4)	
			unit Pa or N m^{-2}	

[9]

4. (Force is 1 N) when a **1 kg** mass has an acceleration of **1 m s**⁻

Not: *'1 kg and 1 m* ***s^{-1}****'*
Allow: *(1 N =)* ***1 kg*** *×* ***1 m s^{-2}***

B1

[1]

5. (i) Kinetic energy = ½ m v^2 C1

= ½ 1380 × $(31.1)^2$ C1

= 667375 (J) (667 kJ) A1

6.7×10^5 (J)

(ii) $v^2 = u^2 + 2as$ C1

$0 = (31.1)^2 + 2 \times a \times 48.2$ A1

a = 10 .0(3) (m s^{-2}) C1

(iii) F = ma or work = force × distance

= 1380 × 10.03 F = 667375 / 48.2 A1

= 13800 (13846) (N) = 13800 (13846) (N)

[7]

6. **Four** from:

Prevents the driver from hitting the steering wheel / windscreen

Deflates quickly to prevent whiplash

Increases the time/distance to stop

Decreases the (impact) force on the driver

Much wider area of the bag reduces the pressure B1 × 4

[4]

7. Any <u>two</u> factors from:

speed, mass, condition of tyres, condition of brakes,

condition of road, gradient of road

Allow*: KE if neither mass nor speed is mentioned.*

B1×2

For each factor, correct description of how braking distance is affected
E.g:

- Greater speed means greater distance
  Or distance ∞ speed^2 (ora)
- Greater mass means greater distance
  Or distance ∞ mass (ora)
- Worn tyres / brakes implies less friction therefore greater distance (ora)
- Wet / slippery / icy road means less friction therefore greater distance (ora)
- Uphill means shorter distance (ora)

For description marks, reference to 'distance' instead of 'braking distance' is fine

For 1st bullet point allow reference to kinetic energy

***Allow**: 'more' or 'longer' instead of 'greater' when referring to distance*

Do not allow 'grip' for friction for 3rd and 4th bullet points

B1×2

[4]

8. 1. (Several) <u>satellites</u> used

B1

2. Distance from (each) satellite is determined

B1

3. Position / distance is determined using c / speed of e.m waves / radio waves / microwaves and delay time (wtte)

B1

4. Trilateration is used to locate the position of the car
   Or position of car is where circles / spheres cross (wtte)

__Note__: The term 'satellite(s)' to be included and spelled correctly,on all occasions, to gain this first (or second) B1 mark (Deduct this mark only <u>once</u>.)

Do not allow this 4th mark for just a diagram of intersecting spheres / circles

B1

[4]

9. (a) $W = mg$

__Allow:__ Use of 9.8 ($m\ s^{-2}$)

weight = $1.50 \times 9.81 = 14.72$ (N) or 14.7 (N) or 15 (N)

Allow: *Bald 15 (N); but* ***not*** *'1.50 × 10 = 15(N)'*

B1

(b) (i) <u>Net</u> / <u>resultant</u> force (on **B**) is less / (net) force (on **B**) is less than its weight / there is tension (in the string) / there is a vertical / upward / opposing force (on **B**)

Note: *Must have reference to force*

B1

(ii) $s = ut + \frac{1}{2}at^2$ <u>and</u> $u = 0$

C1

$1.40 = \frac{1}{2} \times 1.09 \times t^2$

Allow: *2 marks for 1.75/1.09' if answer from (iii) is used*

C1

$t = 1.60$ (s)

Allow: *2 sf answer*

Allow: *2 marks if* ***<u>2.80 m</u>*** *is used; time = 2.27 (s)*

A1

(iii) $v^2 = 2 \times 1.09 \times 1.40$ / $v = 0 + 1.09 \times 1.60$

Possible ecf

C1

$v = 1.75$ ($m\ s^{-1}$) / $v = 1.74$ ($m\ s^{-1}$)

Allow: *1.7 or 1.8 ($m\ s^{-1}$)*

A1

(iv) change in velocity = 2.47 + 1.50 (= 3.97 m s^{-1})

Ignore sign for change in velocity

C1

acceleration = $\dfrac{3.97}{0.030}$

acceleration = 132 (m s^{-2})

Allow: *130 (m s^{-2})*

Special case:

acceleration = $\dfrac{2.47 - 1.50}{0.030}$ *or 32 (m s^{-2}) scores 1 mark*

A1

[9]

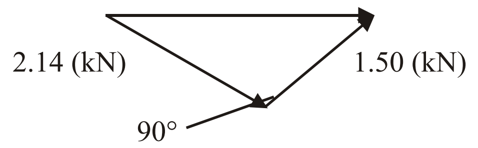
10. The <u>mass</u> of particles increases (at its speed gets closer to the speed of light)

Not*: 'weight of particle increases'*
Not*: 'mass changes / different'*

B1

[1]

11. (i) Correct vector triangle drawn



B1

Note:
Expect at least one 'label' on the sketch, eg: 2.14, 1.5, 90°.
The 'orientation' of the triangle is not important.
The directions of all three arrows are required

(resultant force)^2 = 2.14^2 + 1.50^2

C1

(resultant force) = 261 (kn)

Allow: *2 sf answer of 2.6 (kN)*
Allow *a scale drawing; 2 marks if answer is within ±0.1 kN and 1 mark if ± 0.2 kN*
Alternative *for the C1 A1 marks:*
1.50cos(55) or 2.14cos(35) *C1*
resultant force = 1.50cos(55) + 2.14cos(35)
resultant force = 2.61 (kN) *A1*

A1