

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 Σ) 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**
- $F = 32 \text{ (N)}$
- Note: Bald answer of 32 (N) scores 2/2 marks*
- A1**
- (iii) $p = \frac{32}{6.0 \times 10^{-5}}$
- Possible ecf*
- C1**
- pressure = $5.3 \times 10^5 \text{ (Pa)}$
- Note: Bald answer of $5.3 \times 10^5 \text{ (Pa)}$ 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 B1
- $B \times 110$ or 350×20 B1
- $B = (350 \times 20) / 110$ (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 $3600 \times 1.0 = X \times 2.5$ 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 $3600 \times 1.5 = Y \times 2.5$ 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
- $= 1440 / 2.3 \times 10^{-2}$ 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⁻²**
- Not: '1 kg and 1 m s⁻¹'*
- Allow: (1 N =) **1 kg** × **1 m s⁻²***
- B1
- [1]

5. (i) Kinetic energy = $\frac{1}{2} m v^2$ C1
 $= \frac{1}{2} 1380 \times (31.1)^2$ C1
 $= 667375 \text{ (J) (667 kJ)}$ A1
 $6.7 \times 10^5 \text{ (J)}$
- (ii) $v^2 = u^2 + 2as$ C1
 $0 = (31.1)^2 + 2 \times a \times 48.2$ A1
 $a = 10.0(3) \text{ (m s}^{-2}\text{)}$ C1
- (iii) $F = ma$ or work = force \times distance
 $= 1380 \times 10.03$ $F = 667375 / 48.2$ A1
 $= 13800 \text{ (13846) (N)}$ $= 13800 \text{ (13846) (N)}$

[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 \times 4

[4]

7. Any two 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 \times 2

For each factor, correct description of how braking distance is affected

E.g:

- Greater speed means greater distance
Or distance \propto speed² (ora)
- Greater mass means greater distance
Or distance \propto 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) satellites 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 once.)

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 ' $1.50 \times 10 = 15(N)$ '

B1

- (b) (i) Net / resultant 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) $s = ut + \frac{1}{2}at^2$ and $u = 0$

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 2.80 m 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 = $2.47 + 1.50$ ($= 3.97 \text{ m s}^{-1}$)
Ignore sign for change in velocity

C1

$$\text{acceleration} = \frac{3.97}{0.030}$$

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

Allow: 130 (m s⁻²)

Special case:

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

A1

[9]

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

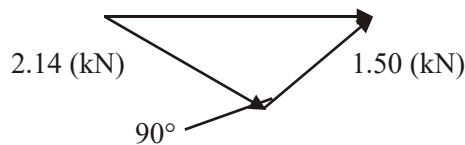
Not: 'weight of particle increases'

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

$$(\text{resultant force})^2 = 2.14^2 + 1.50^2$$

C1

$$(\text{resultant force}) = 261 \text{ (kn)}$$

Allow: 2 sf answer of 2.6 (kN)

Allow a scale drawing; 2 marks if answer is within $\pm 0.1 \text{ kN}$ and 1 mark if $\pm 0.2 \text{ kN}$

Alternative for the C1 A1 marks:

$$1.50\cos(55) \text{ or } 2.14\cos(35) \quad \text{C1}$$

$$\text{resultant force} = 1.50\cos(55) + 2.14\cos(35)$$

$$\text{resultant force} = 2.61 \text{ (kN)} \quad \text{A1}$$

A1

(ii) 2.6(1) (kN)

Possible ecf

B1

(Constant velocity implies) zero net force / zero acceleration

Note: 'resultant force = drag' since the first B1 assumes this

B1

[5]

12. Any three from:

1. (Suspend plate from a point and then) mark a vertical line on the plate (wtte)
2. Plumb line / 'pendulum' (used to find the vertical line)
3. Hang from another point / place (and draw another vertical line) (wtte)
4. Where the lines intersect gives position of centre of gravity (wtte)

Note: For 1st point accept 'mark line of string'

Allow: 1 mark for 'By trial and error find a position where the plate balances'

B1 × 3

[3]

13. (i) net force = 120 (N)

C1

$$a = \frac{120}{900}$$

$$a = 0.13 \text{ (m s}^{-2}\text{)}$$

Note: Bald answer scores 2 marks; answer must be 2 sf or more

A1

(ii) The drag force changes with speed / acceleration is not constant

B1

[3]