

# G481 Mechanics

| Question |         | Expected Answers                                                                                                                                                                                                                                                                                                                                                                           | Marks                                        | Additional Guidance                                                                                                                                                                                                                                                                                   |
|----------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1        | (a)     | A quantity that has (both) magnitude / size and direction                                                                                                                                                                                                                                                                                                                                  | B1                                           | <b>Not</b> 'A quantity that has direction'                                                                                                                                                                                                                                                            |
|          | (b)     | Circled /underlined quantities are:<br>acceleration, displacement and weight                                                                                                                                                                                                                                                                                                               | B1                                           | <b>Note:</b> All three need to be identified for a mark                                                                                                                                                                                                                                               |
|          | (c) (i) | <u>Constant</u> / <u>steady</u> / <u>uniform</u> acceleration (up to 4 s)<br>Or Velocity increases at a <u>steady</u> / <u>constant</u> / <u>uniform</u> rate<br>Or Has acceleration of $3.5 \text{ (m s}^{-2}\text{)}$<br><br><u>Constant</u> / <u>steady</u> / <u>uniform</u> velocity (after 4 s)<br>Or Zero acceleration<br>Or Travels at a velocity of $24 \text{ (m s}^{-1}\text{)}$ | B1<br><br><br><br><br><br><br><br><br><br>B1 | <b>Not</b> Accelerates up to 4 s / 'uniform motion' for the first B1 mark<br><b>Not</b> 'Accelerates at a constant rate'.<br><br><br><br><br><br><br><br><br><br><b>Allow:</b> 'speed' instead of velocity<br><br><b>Allow:</b> 2 mark for 'Constant acceleration and then constant speed / velocity' |
|          | (ii)    | distance = area (under graph)<br><br>distance = 68 (m)                                                                                                                                                                                                                                                                                                                                     | C1<br><br>A1                                 | <b>Allow:</b> The C1 mark is for ... distance = $\frac{1}{2}(10 + 24) \times 4.0$<br><b>Allow:</b> Bald 68 (m) scores 2 marks<br>Bald $\frac{1}{2}(4 \times 14)$ or 28 (m) scores 1 mark for 'area of triangle'                                                                                       |
|          | (iii) 1 | Answer in the range: 1.1 to 1.2 (s)                                                                                                                                                                                                                                                                                                                                                        | B1                                           |                                                                                                                                                                                                                                                                                                       |
|          | (iii) 2 | Same areas under graphs<br><br>$14t = 10t + (0.5 \times 3.5 \times t^2)$<br><br>$t = 2.28 \text{ (s)} \approx 2.3 \text{ (s)}$                                                                                                                                                                                                                                                             | C1<br><br>A1                                 | <b>Note:</b> The C1 mark is for substitution<br><br><b>Allow:</b> Bald 2.3 (s) scores 2 marks<br><b>Allow:</b> Bald ' $t = 2 \times \text{(iii)1.}$ ' Scores 2 marks                                                                                                                                  |
|          |         | <b>Total</b>                                                                                                                                                                                                                                                                                                                                                                               | <b>9</b>                                     |                                                                                                                                                                                                                                                                                                       |

| Question |     | Expected Answers                                                                                                                                                                                                                                                                                  | Marks                                                                    | Additional Guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|----------|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2        | (a) | Downward arrow at <b>P</b>                                                                                                                                                                                                                                                                        | <b>B1</b>                                                                | Arrow must be close to or at point <b>P</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|          | (b) | From <u>gravitational</u> potential (energy) to kinetic (energy) / KE / $E_k$ (wtte)<br><br>Any further detail:<br>KE maximum at bottom / Zero (G)PE at bottom / (G)PE is maximum at top / (G)PE and KE at top (wtte)                                                                             | <b>B1</b><br><br><b>B1</b>                                               | The term gravitational to be included and spelled correctly in (b) to gain the <u>first</u> B1 mark<br><br><b>Not:</b> Heat / sound at ground                                                                                                                                                                                                                                                                                                                                                    |
|          | (c) | The acceleration / force / weight is at right angles to horizontal motion / velocity (wtte)                                                                                                                                                                                                       | <b>B1</b>                                                                | <b>Allow:</b> 'In this direction the force / acceleration is zero'                                                                                                                                                                                                                                                                                                                                                                                                                               |
|          | (d) | time = $\frac{3.6}{7.0}$ (= 0.514 s)                                                                                                                                                                                                                                                              | <b>B1</b>                                                                | <b>Allow:</b> time = $\sqrt{(1.3 \times 2) / 9.81}$ (= 0.515 s)<br><b>Allow:</b> Use of 9.8 (m s <sup>-2</sup> )                                                                                                                                                                                                                                                                                                                                                                                 |
|          | (e) | $u = 0$ <u>and</u> $v = u + at$ or $v^2 = u^2 + 2as$<br><br>'vertical' velocity = $9.81 \times 0.5(14)$<br>or<br>'vertical' velocity = $\sqrt{2 \times 9.81 \times 1.3}$<br><br>'vertical' velocity = 5.0 (m s <sup>-1</sup> )<br><br>$v^2 = 7.0^2 + 5.0^2$<br><br>$v = 8.6$ (m s <sup>-1</sup> ) | <b>C1</b><br><br><br><br><br><b>C1</b><br><br><b>C1</b><br><br><b>A0</b> | <b>Watch out for:</b><br>' $v^2 = u^2 + 2as = 7^2 + (2 \times 9.81 \times 1.3) = 8.6$ ' – this scores <b>no</b> marks because of <b>wrong</b> physics.<br><br><b>Note:</b> Getting an answer 5.0 (m s <sup>-1</sup> ) scores the first 2 marks<br><br><b>Note:</b> Using $t = 0.5$ (s) gives 8.55 (m s <sup>-1</sup> )<br><b>Note:</b> Bald answer scores zero marks – since this is a 'show' question<br>(Allow full marks for correct analysis using the principle of conservation of energy.) |
|          |     | <b>Total</b>                                                                                                                                                                                                                                                                                      | <b>8</b>                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

| Question |     |      | Expected Answers                                                                                                                                                                          | Marks                                       | Additional Guidance                                                                                                                                 |
|----------|-----|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| 3        | (a) |      | (Force is 1 N ) when a <b>1 kg</b> mass has an acceleration of <b>1 m s<sup>-2</sup></b>                                                                                                  | <b>B1</b>                                   | <b>Not:</b> '1 kg and 1 m s <sup>-1</sup> ',<br><b>Allow:</b> (1 N =) <b>1 kg</b> × <b>1 m s<sup>-2</sup></b>                                       |
|          | (b) |      | The <u>mass</u> of particles increases (at its speed gets closer to the speed of light)                                                                                                   | <b>B1</b>                                   | <b>Not:</b> 'weight of particle increases'<br><b>Not:</b> 'mass changes / different'                                                                |
|          | (c) | (i)  | net force = 120 (N)<br>$a = \frac{120}{900}$<br>$a = 0.13 \text{ (m s}^{-2}\text{)}$                                                                                                      | <b>C1</b><br><br><b>A1</b>                  | <br><br><b>Note:</b> Bald answer scores 2 marks; answer must be 2 sf or more                                                                        |
|          |     | (ii) | The drag force changes with speed / acceleration is not constant                                                                                                                          | <b>B1</b>                                   |                                                                                                                                                     |
|          | (d) |      | $F = 72 \times 1.4 \text{ (= 100.8 N)}$ / weight = $72 \times 9.81 \text{ (= 706.32 N)}$<br><br>$T = (72 \times 9.81) + (72 \times 1.4)$<br><br>$T = 807 \text{ (N) or } 810 \text{ (N)}$ | <b>C1</b><br><br><b>C1</b><br><br><b>A1</b> | <b>Note:</b> Bald 101 (N) or 706 (N) scores 1 mark<br><br><br><b>Note:</b> Bald answer scores 3 marks<br>Bald 605.52 to at least 2 sf scores 1 mark |
|          |     |      | <b>Total</b>                                                                                                                                                                              | <b>8</b>                                    |                                                                                                                                                     |

| Question |     |      | Expected Answers                                                                                                                                                                                                                                                                                                                    | Marks                  | Additional Guidance                                                                                                                                                               |
|----------|-----|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 4        | (a) |      | torque of a couple = one of forces $\times$ <u>perpendicular</u> distance (between forces)                                                                                                                                                                                                                                          | B1                     | <b>Not:</b> ‘force $\times$ perpendicular distance’                                                                                                                               |
|          | (b) |      | Torque and moment are to do with ‘distance multiplied by force’                                                                                                                                                                                                                                                                     | B1                     |                                                                                                                                                                                   |
|          | (c) | (i)  | moment = $6.0 \times 0.40$<br>moment = 2.4 (N m)                                                                                                                                                                                                                                                                                    | B1                     |                                                                                                                                                                                   |
|          |     | (ii) | Weight / force acts through the pivot<br>Or (perpendicular) distance from pivot is (reduced to) zero (wtte)                                                                                                                                                                                                                         | B1                     | <b>Allow:</b> weight is ‘vertically below’ / ‘directly below’ the pivot<br>Reference to pivot / point <b>P</b> (wtte) is essential                                                |
|          | (d) |      | Any <u>three</u> from:<br>1. (Suspend plate from a point and then) mark a vertical line on the plate (wtte)<br>2. Plumb line / ‘pendulum’ (used to find the vertical line)<br>3. Hang from another point / place (and draw another vertical line) (wtte)<br>4. Where the lines intersect gives position of centre of gravity (wtte) | B1 $\times$ 3          | <b>Note:</b> For 1st point accept ‘mark line of string’<br><br><b>Allow:</b> 1 mark for ‘By trial and error find a position where the plate balances’                             |
|          | (e) |      | (sum of) clockwise moment(s) = (sum of ) anticlockwise moment(s)<br>$(18 \times 0.14) + (60 \times 0.32) = 0.035F$<br><br>$F \approx 620$ (N)                                                                                                                                                                                       | C1<br><br>C1<br><br>A1 | <b>Not:</b> ‘CWM = ACWM’<br><br><b>Allow:</b> working in consistently in cm<br><br><b>Note:</b> Bald answer scores 3 marks<br><b>Allow:</b> 1 mark for 21.72 (N m) or 2172 (N cm) |
|          |     |      | <b>Total</b>                                                                                                                                                                                                                                                                                                                        | <b>10</b>              |                                                                                                                                                                                   |

| Question |     | Expected Answers                                                                                           | Marks                                                                                                                                                                                                                                                            | Additional Guidance                                                                                                                                                                                                                                                                                                                                                                                                                                           |
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| 5        | (a) | $F_H = 20 \cos 38 = 15.76 \approx 15.8 \text{ (N)}$<br>$F_V = 20 \sin 38 = 12.31 \approx 12.3 \text{ (N)}$ | <b>B1</b><br><br><b>B1</b>                                                                                                                                                                                                                                       | <b>Allow:</b> 2 sf answers of 16 (N) and 12 (N)<br><br><b>Allow:</b> 1 mark if vertical and horizontal components have been interchanged                                                                                                                                                                                                                                                                                                                      |
|          | (b) | (i)                                                                                                        | net force vertically = 0 / weight = upward forces<br><br>weight = 12.3 + 12.3<br><br>weight = 24.6 (N) $\approx$ 25 (N)<br>----- Or -----<br>correct triangle of forces diagram<br><br>correct determination of weight<br><br>weight = 24.6 (N) $\approx$ 25 (N) | <b>C1</b><br><br><b>C1</b><br>Possible ecf from $F_V$ value from (a)<br><br><b>A0</b><br><br><b>C1</b><br>At least one label needed (e.g: 20, correct angle, etc) – arrows not needed<br><br><b>C1</b><br>Weight in the range 22 – 27 (N)<br><br><b>A0</b>                                                                                                                                                                                                    |
|          |     | (ii)                                                                                                       | $\text{mass} = \frac{25}{9.81} = 2.55 \text{ (kg)}$<br><br>$\text{density} = \frac{2.55}{2.9 \times 10^{-4}}$<br>$\text{density} = 8.8 \times 10^3 \text{ (kg m}^{-3}\text{)}$                                                                                   | <b>C1</b><br><br><b>C1</b><br><br><b>A1</b><br><b>Note:</b> 'weight/volume' scores zero<br><b>Note:</b> Answer is $8.7 \times 10^3$ if 2.51 kg is used<br><b>Allow:</b> 2 marks if $g = 10$ used and 25 N $\rightarrow$ 2.5 kg $\therefore \rho = 8620 \text{ (kg m}^{-3}\text{)}$<br><b>Note:</b> Bald $8.7 \times 10^3$ or $8.8 \times 10^3$ scores 3 marks<br><b>Allow:</b> 1 mark if 20 N is used instead of 25 N – this gives 7030 (kg m <sup>-3</sup> ) |
|          |     | <b>Total</b>                                                                                               | <b>7</b>                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

| Question |     | Expected Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Marks                                   | Additional Guidance                                                                                                                                                                                                                                                                                                                                                                                                      |
|----------|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6        | (a) | stopping distance = thinking distance + braking distance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | B1                                      |                                                                                                                                                                                                                                                                                                                                                                                                                          |
|          | (b) | <p>Any <u>two</u> factors from:<br/> speed, mass, condition of tyres, condition of brakes,<br/> condition of road, gradient of road</p> <p>For each factor, correct description of how braking distance is affected<br/> E.g:</p> <ul style="list-style-type: none"> <li>Greater speed means greater distance<br/> Or distance <math>\propto</math> speed<sup>2</sup> (ora)</li> <li>Greater mass means greater distance<br/> Or distance <math>\propto</math> mass (ora)</li> <li>Worn tyres / brakes implies less friction<br/> therefore greater distance (ora)</li> <li>Wet / slippery / icy road means less friction<br/> therefore greater distance (ora)</li> <li>Uphill means shorter distance (ora)</li> </ul> | <p>B1×2</p> <p>B1×2</p>                 | <p><b>Allow:</b> KE if neither mass nor speed is mentioned.</p> <p>For description marks, reference to 'distance' instead of 'braking distance' is fine</p> <p>For 1<sup>st</sup> bullet point allow reference to kinetic energy</p> <p><b>Allow:</b> 'more' or 'longer' instead of 'greater' when referring to distance</p> <p>Do not allow 'grip' for friction for 3<sup>rd</sup> and 4<sup>th</sup> bullet points</p> |
|          | (c) | <ol style="list-style-type: none"> <li>(Several) <u>satellites</u> used</li> <li>Distance from (each) satellite is determined</li> <li>Position / distance is determined using <math>c</math> / speed of e.m waves / radio waves / microwaves and delay time (wtte)</li> <li>Trilateration is used to locate the position of the car<br/> Or position of car is where circles / spheres cross (wtte)</li> </ol>                                                                                                                                                                                                                                                                                                         | <p>B1</p> <p>B1</p> <p>B1</p> <p>B1</p> | <p><b>Note:</b> 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>.)</p> <p>Do not allow this 4<sup>th</sup> mark for just a diagram of intersecting spheres / circles</p>                                                                                                                                        |
|          |     | <b>Total</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>9</b>                                |                                                                                                                                                                                                                                                                                                                                                                                                                          |

| Question |     |       | Expected Answers                                                                                                                                                             | Marks            | Additional Guidance                                                                                                                                                                 |
|----------|-----|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7        | (a) |       | elastic potential (energy) / strain (energy)                                                                                                                                 | B1               | <b>Note:</b> The candidates do not need to include 'energy' since it is in the stem of the question<br><b>Not:</b> 'stored energy' / 'elastic energy'                               |
|          | (b) | (i)   | $\text{strain} = \frac{0.35 \times 10^{-3}}{1.2} = 2.9(2) \times 10^{-4}$                                                                                                    | B1               |                                                                                                                                                                                     |
|          |     | (ii)  | stress = $1.9 \times 10^{11} \times 2.92 \times 10^{-4}$<br>(= $5.55 \times 10^7$ Pa)<br><br>tension = $5.55 \times 10^7 \times 1.4 \times 10^{-7}$<br><br>tension = 7.8 (N) | C1<br><br><br>A1 | Possible ecf from <b>b(i)</b><br><br><b>Allow:</b> Bald answer scores 2 marks                                                                                                       |
|          | (c) | (i) 1 | $10^{-9}$ (m)                                                                                                                                                                | B1               |                                                                                                                                                                                     |
|          |     | (i) 2 | Material does not return to original length / shape / size when the force / stress is removed                                                                                | B1               | There must be reference to stress / force removed to score this mark<br><br><b>Note:</b> If there is no reference to unloading then allow 'material is <u>permanently</u> deformed' |
|          |     | (ii)  | 50 times (stronger)                                                                                                                                                          | B1               |                                                                                                                                                                                     |
|          |     | (iii) | Less mass / less weight / lighter<br>Stronger / greater tensile strength                                                                                                     | B1<br>B1         |                                                                                                                                                                                     |
|          |     |       | <b>Total</b>                                                                                                                                                                 | <b>9</b>         |                                                                                                                                                                                     |