G481 Mechanics

CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

B marks: These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

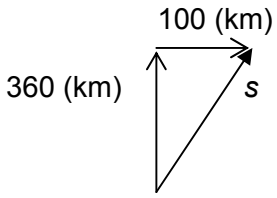
M marks: These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

A marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

SIGNIFICANT FIGURES

In general, there is no penalty when the candidate's answer is more than the sf of the data given in the question.
For example, in a question where the data is given to 2 sf, the answer can be 2 sf or more. An answer given to 1 sf may be penalised.

Question			Expected Answers	Marks	Additional Guidance
1	(a)	(i)	Both measured in metre/m	B1	**Allow**: Both have the same unit/Both have 'magnitude' **Not**: Both are distance/length
		(ii)	Distance is a scalar/does not have direction or Displacement is a vector/has direction	B1	**Not**: One is a vector and the other a scalar
	(b)	(i)	time = $\frac{3.6\times10^5}{170}$ time = 2.1(18) $\times$ 10^3 (s) or 2.1 $\times$ 10^3 (s)	B1	**Note**: Answer to 2sf or more is required
		(ii)	Correct vector triangle Eg:  $s^2 = 360^2 + 100^2$ / $s = \sqrt{(360^2 + 100^2)}$ *s* = 373.6 (km) / 370 (km)	B1 C1 A1	The vector triangle must have at least two labels (360, 100 and *s* – allow *x* or *d* for *s*). The 'orientation' of the triangle must be as shown. Ignore the direction of the arrows. **Allow**: Full credit can be given for a scale drawing 2 marks if answer in the range (370 – 380) 1 mark if answer in the range (360 – 370) or (380 - 390) **Note**: Bald answer to 2sf or more and no diagram scores 2/3 marks.
			Total	**6**	

Question			Expected Answers	Marks	Additional Guidance
2	(a)	(i)	*a* = gradient/slope (of the line)	B1	**Allow**: *a* = change in velocity/time or 'rate of change of velocity' **Allow**: Correct equation plus labels; $a = (v-u)/t$; *v* = final velocity, *u* = initial velocity and *t* = time **Note**: The term *gradient*/*slope*/*change*/ *initial* to be included and spelled correctly to gain mark
		(ii)	*s* = area (under the graph)	B1	
	(b)		area of 'rectangle' = '*ut*' area of 'triangle' = $\frac{1}{2} \times t \times (v-u)$ area of 'triangle' = $\frac{1}{2} \times t \times at$	M1 M1	**Note**: The second M1 mark is **not** for '½ at^2' but for ' ½ × *t* × *at*' **Allow**: 'Area of trapezium method': $s = \frac{1}{2}(u+v)t$ and $v = u + at$ M1 Correct substitution leading to correct answer M1 **Note**: Substitution method starting with $v^2 = u^2 + 2as$ scores zero
	(c)	(i)	$32 = \frac{1}{2} \times a \times 2.8^2$ $a = \frac{32 \times 2}{2.8^2}$ *a* = 8.16 (m s^{-2}) or 8.2 (m s^{-2})	C1 A1	**Note**: The C1 mark is for substitution into the equation given in **(b)** with *u* = 0 **Note**: Bald answer of 8.16 (m s^{-2}) or 8.2 (m s^{-2}) scores 2/2 marks Bald 8 (m s^{-2}) scores 1/2
		(ii)	Drag/air resistance/air friction (makes the time longer)	B1	**Not:** 'Reaction time'/'wind'
			Total	**7**	

Question			Expected Answers	Marks	Additional Guidance
3	(a)		… ***immediately*** *after jumping* Only force is the weight/drag = 0/net force = weight acceleration = *g*/9.8(1 m s^{-2}) (Allow '*mg*' for weight. Do not allow 'gravity' for weight.) … ***before*** *terminal velocity is reached* Any **<u>two</u>** from: Drag increases (with speed) /drag $\propto$ $speed^2$ Net or resultant or total force decreases / weight > drag Acceleration is less than *g* … ***at*** *terminal velocity* weight = drag / net force = 0 acceleration = 0 /<u>constant</u> speed or velocity (AW)	B1 B1 B1 B1 B1 B1 B1	**Alternatives** accepted for *drag* are: friction/air resistance **Allow**: 'Has acceleration of free-fall/due to gravity' as alternative for second B1 mark **Allow**: velocity instead of speed. **Allow**: 'drag $\propto$ speed' as BOD. **Allow**: Acceleration decreases **Allow**: upward force(s) = downward force/'forces balanced'
	(b)		(Transformed to) heat/thermal (energy)	B1	**Not**: 'Friction'/sound
	(c)		Any **<u>two</u>** from: 1. The terminal velocity increases 2. Initial gradient/slope is the same/equal to *g* 3. Time taken to reach terminal velocity is longer	B1 $\times$ 2	 **Allow**: Initial acceleration is the same/*g*/9.8(1 m s^{-2})
			Total	**9**	

Question			Expected Answers	Marks	Additional Guidance
4	(a)		work done = force × distance <u>moved</u> in the direction of the force	M1 A1	**Allow**: 'displacement' instead of 'distance' **Allow**: 1 mark for 'force × distance in the direction of the force' **Not**: work done = energy transfer
	(b)		power = work (done)/time or power = energy/time or power = rate of work done	B1	**Not**: Mixture of quantities and units, e.g: 'energy per second'
	(c)		This is because of heat/thermal energy/friction	B1	**Not**: sound/vibrations
	(d)	(i)	$E_k = \frac{1}{2}mv^2$ / $E_k = \frac{1}{2} \times 810 \times 30^2$ $E_k = 3.645 \times 10^5$ (J) or 3.65×10^5 (J)	C1 A1	**Note**: Bald answer 3.645×10^5 (J) or 3.6×10^5 (J) scores 2/2 marks **Allow**: 1 mark for wrongly rounded answer of 3.7×10^5 (J)
		(ii)	power = $\frac{3.65 \times 10^5}{12}$ power = 3.04×10^4 (W) ≈ 3.0×10^4 (W)	B1	Possible ecf
		(iii) 1.	work done = 500 × 30 work done = 15000 (J s^{-1})	B1	
		2.	'output energy' = $18 \times 46 \times 10^6 \times 0.25$ (= 2.07×10^8 J)	C1	**Allow**: 'input energy' = $18 \times 46 \times 10^6$ (= 8.28×10^8 J)
			total drive time = $\frac{18 \times 46 \times 10^6 \times 0.25}{15000}$ (= 1.38×10^4s)	C1	This C1 mark can also be scored using: 'distance = $2.07 \times 10^8/500$' Possible ecf from **iii 1.**
			total drive distance = $1.38 \times 10^4 \times 30$ = 4.1×10^5 (m)	A1	**Allow**: Bald 4.1×10^5 (m) scores 3/3 2/3 for 1.66×10^6 m if 25% efficiency is not used 2/3 if 30 kW from **ii** is used; answer 2.0 or 2.1×10^5 (m)
			Total	**11**	

Question			Expected Answers	Marks	Additional Guidance
5	(a)	(i)	*N* is normal to the ramp (judged by eye) *F* is parallel and up the ramp	B1 B1	Allow marks even if the labels *N* and *F* are omitted
		(ii)	$F = W\sin\theta$	B1	
	(b)	(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) Reference to one of the moments taken about a point/'equilibrium'/sum (or total or net or Σ) mentioned once	 M1 A1	**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 **Note**: If M1 is lost for incorrect spelling of 'clockwise', then allow this A1 mark
		(ii)	$200\times12 = F\times75$ $F = 32$ (N)	C1 A1	**Note**: Bald answer of 32 (N) scores 2/2 marks
		(iii)	$p = \frac{32}{6.0\times10^{-5}}$ pressure = 5.3×10^5 (Pa)	C1 A1	Possible ecf **Note**: Bald answer of 5.3×10^5 (Pa) scores 2/2 marks
		(iv)	(Pressure is) greater because the force/*F* is larger (to provide the same moment)	B1 B1	
			Total	**11**	

Question			Expected Answers	Marks	Additional Guidance
6	(a)		time = $6.9 \times 3.16 \times 10^7$ (= 2.18×10^8 s) average speed = $\frac{5.0 \times 10^{12}}{6.9 \times 3.16 \times 10^7}$ average speed = 2.29×10^4 or 2.3×10^4 (m s^{-1})	C1 A1	**Allow**: 1 mark for $5.0 \times 10^{12}/6.9 = 7.2(46) \times 10^{11}$ (m y^{-1}) **Allow**: 1 mark for $\frac{5.0 \times 10^{12}}{3.16 \times 10^7} = 1.58 \times 10^5$ (m s^{-1})
	(b)		distance = 0.70×200 (= 140 mm) or KE = ½ × $4.0 \times 10^{-6} \times 6100^2$ (= 74.4 J) work done = change in KE $F \times (0.70 \times 10^{-3} \times 200) = \frac{1}{2} \times 4.0 \times 10^{-6} \times 6100^2$ *F* = 530 (N) ---------- or ---------- *F* = *ma* $a = \frac{6100^2}{2 \times (0.70 \times 10^{-3} \times 200)}$ (=1.33×10^8) *F* = $4.0 \times 10^{-6} \times 1.33 \times 10^8$ *F* = 530 (N)	C1 C1 A1 C1 C1 A1	**Note**: Bald answer scores 3/3 marks **Note**: 0.53 (N) scores 2/3 because of 10^n error in distance 1.06×10^5 (N) scores 2/3 because '200' not taken into account 106 (N) scores 1/3 because '200' missed out and 10^n error
			Total	**5**	

Question			Expected Answers	Marks	Additional Guidance
7	(a)		Straight line through origin (judge by eye) Correct shape of curve in the plastic region	B1 B1	
	(b)		Copper	B1	
	(c)		Maximum stress material can withstand (before fracture)	B1	**Allow**: UTS = breaking stress **Allow**: UTS = breaking force /(cross-sectional) area
	(d)		extension (or compression) $\propto$ force (as long as elastic limit is not exceeded)	B1	**Allow**: 'load' instead of force **Not**: $x \propto F$, unless the labels are defined
	(e)	(i)	force = 75×0.085 F = 6.38 (N) $\approx$ 6.4 (N)	C1 A1	
		(ii)	acceleration = $\dfrac{6.38}{2.5\times10^{-3}}$ acceleration = 2550 (m s^{-2})	B1	**Note**: $a = \dfrac{kx - mg}{m}$ gives 2540 (m s^{-2}) Possible ecf
		(iii)	Correct selection of equation: mgh / $\frac{1}{2}kx^2$ / $\frac{1}{2}Fx$ $0.0025\times9.81\times h = \dfrac{1}{2}\times75\times0.085^2$ height = 11 (m)	C1 C1 A1	 **Note**: Bald answer of 11 (m) scores 3/3 marks
			Total	**11**	