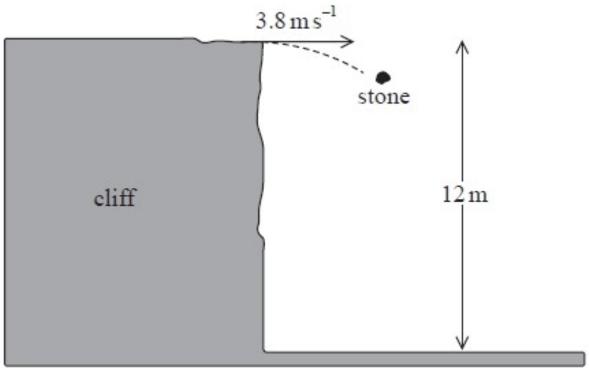
# Questions

**Q4.**

A stone is projected horizontally from a cliff. The initial horizontal velocity of the stone is 3.8 m s$^{-1}$.

The initial height of the stone is 12 m, as shown.




Calculate the horizontal distance from the bottom of the cliff to where the stone hits the ground.

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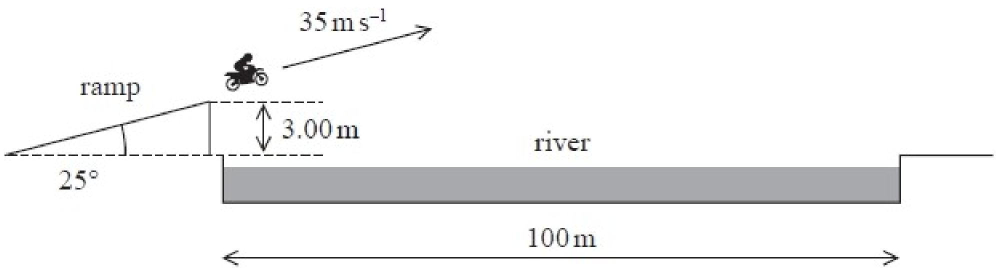
Horizontal distance = ..........................................................

**Q5.** **(Total for question = 3 marks)**

A stunt motorcyclist wants to jump across a river to land on the other side. The diagram shows the motorcyclist driving off a ramp at the edge of a river.




The ramp is at an angle of 25° to the horizontal and the height at the end of the ramp is 3.0 m.
The width of the river is 100 m. The initial velocity of the motorcyclist is 35 m s$^{-1}$.

(a) Calculate the horizontal and vertical components of the motorcycle's initial velocity as it leaves the ramp.

**(2)**

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Horizontal component = ..........................................................

Vertical component = ..........................................................

(c) Explain how air resistance would affect the jump.

**(3)**

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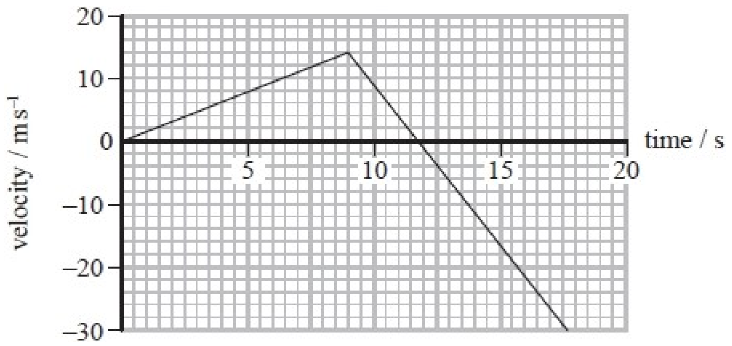
**(Total for question = 9 marks)**

**Q6.** The graph shows how the velocity of an object varies with time.




Describe how the acceleration of the object varies with time.
Your answer should include calculations.

**(3)**

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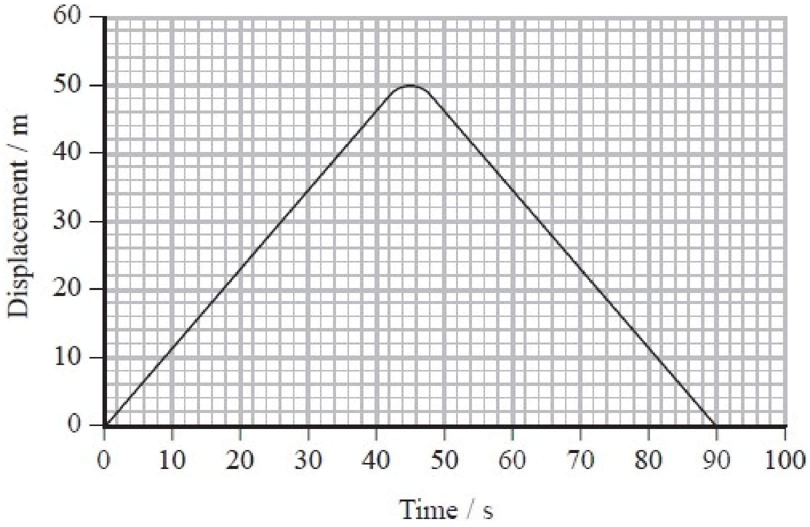
**Q7.**

A swimmer swims a 100 m race. A simplified displacement-time graph for the swimmer is shown.




(a) Draw a corresponding velocity-time graph for the motion of the swimmer on the axes below.

Show all working in the space below.

**(4)**

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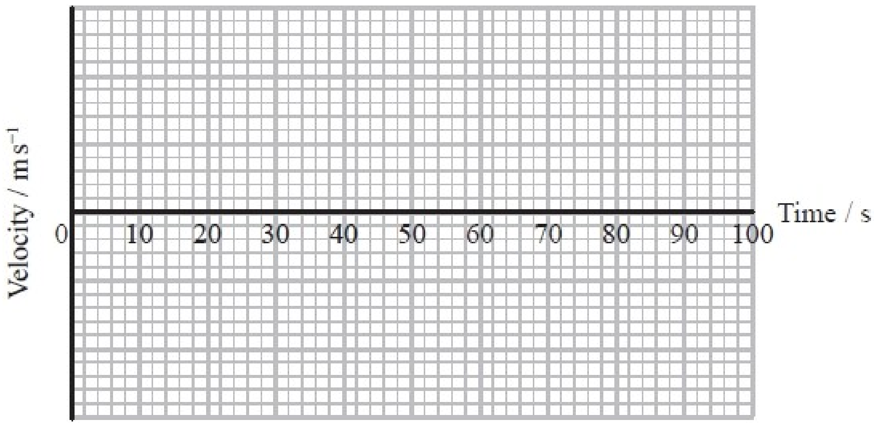
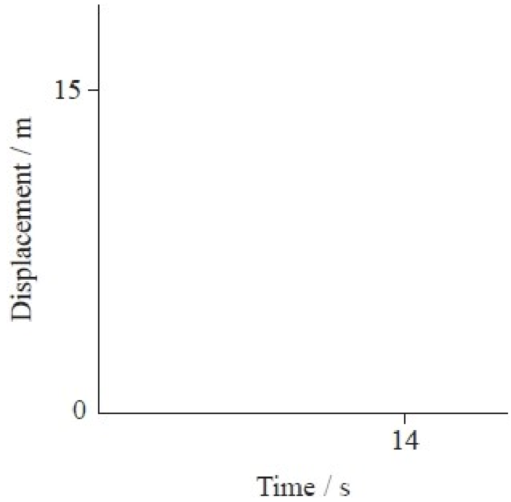



(b) To increase her initial speed, the swimmer began the race by gliding underwater for 15 m and then began to use her arms and legs. This was not represented on the simplified displacement-time graph.

(i) Sketch onto the axes below to show the actual variation of displacement with time for the first 15 m of the race.

**(2)**




(ii) Explain one other way in which the motion of the swimmer has been simplified when drawing the displacement-time graph.

**(2)**

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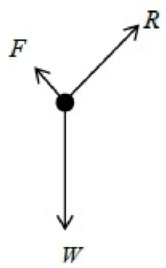
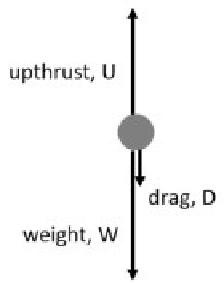
**(Total for question = 8 marks)**

| Question Number | Answer | | Mark |
|---|---|---|---|
| (a) | • Weight/*W*/*mg* labelled<br>• (Normal) reaction/contact force (accept *R*/*N*/*C*)<br>• Friction/*F*<br>• Lengths $R<W$ **and** $F<W$<br>( -1 off total for each additional arrowed line and MP4 conditional on MP1, 2 **and** 3)<br>(do not accept components of forces, even if both given and accept correct direction/size by eye)<br><br> | (1)<br>(1)<br>(1)<br>(1) | 4 |
| (b)(i) | • Initially friction/drag negligible/small/less (as the velocity is low)<br>• See $mg\sin\theta$ **Or** $W\sin\theta$<br>• $mg\sin\theta = ma$ and the masses cancel (so *a* independent of *m*) | (1)<br>(1)<br>(1) | 3 |
| (b)(ii) | • As velocity increases, air resistance increases<br>• Until frictional forces = component of weight down slope<br>• Resultant force = 0 **and** there is no more acceleration (at max velocity)<br>(MP2 allow frictional forces = $mg \sin\theta$) | (1)<br>(1)<br>(1) | 3 |
| (b)(iii) | • A larger person would have a greater area/volume<br>• The air resistance would be greater (accept drag) | (1)<br>(1) | 2 |

| | | | |
|---|---|---|---|
| (c)(i) | See $\theta = \tan^{-1} 0.2$ **and** $\theta = 11.3°$<br>**Or** see $\tan\theta = 0.2$ **and** $\theta = 11.3°$ | (1) | 1 |
| (c)(ii) | **Either** (Energy)<br>Use of $E_k = ½ mv^2$<br>Use of trig to determine the component of weight along the slope or the vertical height in terms of $L$<br>Use of $E_{grav} = mg\Delta h$ (to determine $E_{grav}$) **Or** use of $W = F\Delta s$<br>Use of of $E_k = E_{grav} + W$ (to determine<br>$L = 120$ m<br><br>**Or** (forces)<br>Use of trig to determine the component of weight along the slope or the vertical height in terms of $L$<br>Use of resultant force = $mg\sin 11.3° + 240$ N<br>Use of $\Sigma F = ma$ to determine $a$<br>Use of $v^2 = u^2 + 2as$ with their $a$ (not 9.81) to determine $s$<br>$L = 120$ m<br><u>Example of calculation</u><br>$E_k = ½ \times 95 \text{ kg} \times (33 \text{ m s}^{-1})^2 = 51728$ J<br>51728 J = $(95 \text{ kg} \times 9.81 \text{ N kg}^{-1} \times \sin 11.3° \times L) + (240 \text{ N} \times L)$<br>$L = 122$ m | (1)<br>(1)<br>(1)<br>(1)<br>(1)<br><br>(1)<br>(1)<br>(1)<br>(1)<br>(1) | 5 |
| | **Total for question** | | **18** |

**Q3.**

| Question Number | Answer | | Mark |
|---|---|---|---|
| (a) | • Weight **Or** $W$, downwards<br>• Drag **Or** $D$, downwards<br> | (1)<br>(1) | 2 |
| (b) | • Use of $V = \frac{4}{3}\pi r^3$<br>• Use of $\rho = \frac{m}{V}$ and $W = mg$<br>• Upthrust = $3.06 \times 10^{-4}$ (N)<br><br><u>Example of calculation</u><br>Volume of bead = $4/3 \times \pi \times (2.00 \times 10^{-3}\text{ m})^3 = 3.35 \times 10^{-8}\text{ m}^3$<br>Weight of displaced fluid = $930\text{ kg m}^{-3} \times 3.35 \times 10^{-8}\text{ m}^3 \times 9.81\text{ N kg}^{-1}$<br>$= 3.06 \times 10^{-4}$ N | (1)<br>(1)<br>(1) | 3 |
| (c)(i) | • The flow must be laminar<br>**Or** There must be no turbulent flow | (1) | 1 |
| (c)(ii) | • States $D = U - W$<br>• Use of $F = 6\pi\eta rv$<br>• $v = 0.16$ (m s$^{-1}$)<br>• Calculate $v_R = 0.13$ (m s$^{-1}$)<br>• Comparison of $v$ with $v_R$ and correct conclusion (ecf from (b))<br><br>Alternative method of comparison of $F(0.13)$ with $D$ scores full marks.<br><br><u>Example of calculation</u><br>$U - W = 3.06 \times 10^{-4} - 1.05 \times 10^{-5} = 2.96 \times 10^{-4}$ N<br>$v = 2.96 \times 10^{-4}\text{ N} / (6\pi \times 4.9 \times 10^{-2}\text{ Pa s} \times 2.0 \times 10^{-3}\text{ m}) = 1.60 \times 10^{-1}\text{ m s}^{-1}$<br>$v_R = 10 \times 4.9 \times 10^{-2}\text{ Pa s} / (930\text{ kg m}^{-3} \times 4.0 \times 10^{-3}\text{ m}) = 1.32 \times 10^{-1}\text{ m s}^{-1}$ | (1)<br>(1)<br>(1)<br>(1)<br>(1) | 5 |
| | **Total for question** | | 11 |

**Q4.**

| Question Number | Answer | | Mark |
|---|---|---|---|
| | Use of $s = ut + ½at^2$ with $u = 0$ and $a = g$ for flight time<br>Use of $s = ut + ½at^2$ with $a = 0$ for horizontal displacement of stone<br>Distance travelled = 5.9 m<br><br><u>Example of calculation</u><br>$12\text{ m} = 0.5 \times 9.81\text{ m s}^{-2} \times t^2$<br>$t = \sqrt{(12.0\text{ m} \div 4.905\text{ m s}^{-2})} = 1.56$ s<br>$s_{stone} = 3.8\text{ m s}^{-1} \times 1.56\text{ s} = 5.94$ m | (1)<br>(1)<br>(1) | 3 |
| | **Total for question** | | 3 |

**Q5.**

| Question Number | Answer | | Mark |
|---|---|---|---|
| (a) | Use of appropriate trigonometry | (1) | |
| | $v_x$ =32 m s$^{-1}$ **and** $v_y$ =15 m s$^{-1}$ | (1) | 2 |
| | Example of calculation<br>$v_x$ =35 m s$^{-1}$ × cos 25° = 31.7 m s$^{-1}$<br>$v_y$ =35 m s$^{-1}$ × sin 25° = 14.8 m s$^{-1}$ | | |

| | | | |
|---|---|---|---|
| (b) | Use of $s = u_x t$ to find time taken to travel 100 m horizontally | (1) | |
| | Use of $s = u_y t + ½ a t^2$ with $a = - g$ to find distance fallen in time $t$<br>Accept other correct SUVAT methods | (1) | |
| | Distance fallen = 2.1 m | (1) | |
| | Conclusion consistent with comparison of student's values,<br>e.g. 2.1 m < 3.0 m so rider lands on other side of river | (1) | |
| | **Or** | | |
| | Use of correct SUVAT method with $a = - g$ to find time to descend by 3 m. | (1) | |
| | Use of $s = u_x t$ to find horizontal distance travelled in time $t$. | (1) | |
| | Distance travelled = 102 m | (1) | |
| | Conclusion consistent with comparison of student's values | (1) | |
| | **Or** | | |
| | Use of $s = u_x t$ to find time taken to travel 100 m horizontally | (1) | |
| | Use of correct SUVAT method with $a = - g$ to find time to descend by 3 m. | (1) | |
| | Time = 3.21 s | (1) | |
| | Conclusion consistent with comparison of student's values,<br>e.g. 3.15 s < 3.21 s so rider lands on other side of river | (1) | 4 |
| | Example of calculation<br>time taken to travel 100 m = 100 m ÷ 31.7 m s$^{-1}$ = 3.15 s<br>vertical displacent = 14.8 × 3.15 − 0.5 × 9.81 × 3.15$^2$ = − 2.12 m<br>2.1 m < 3.0 m, so rider lands on other side of river | | |

| (c) | Air resistance act to oppose the motion of the motorcyclist **(1)**<br><br>So it decreases the time for which the motorcyclist is in the air<br>**Or**<br>There is deceleration in the horizontal direction<br>**Or**<br>Speed in horizontal direction is reduced<br>**Or**<br>The (maximum) height reached by the motorcyclist is reduced **(1)**<br><br>Horizontal distance travelled is reduced (dependent on MP1 or MP2) **(1)** | **3** |
|---|---|---|
| | **Total for question** | **9** |

**Q6.**

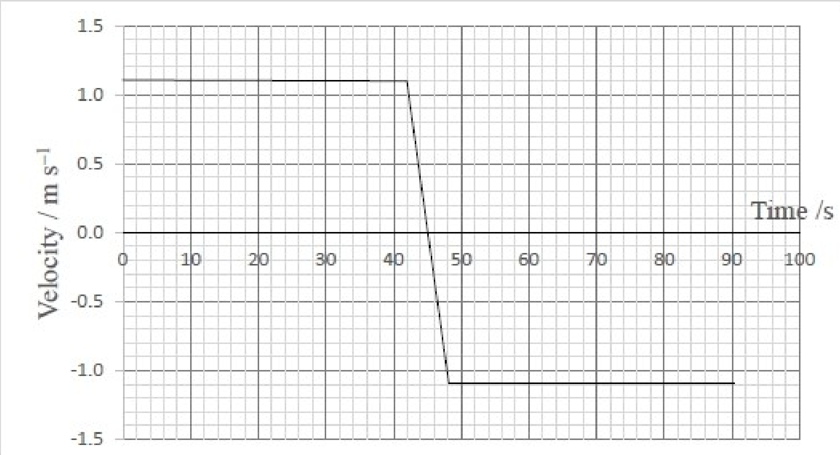
| Question Number | Answer | Mark |
|---|---|---|
| | • Use of $a = \frac{v-u}{t}$ (1)<br>• See 1.6 m $s^{-2}$ **Or** see (−)4.9 to (−)5.2 m $s^{-2}$ (1)<br><br>**Max 1**<br>• At 9 s the acceleration becomes negative (1)<br>• From 9 s to 12 s the object is decelerating (1)<br>• From 12 s to 17.5 seconds the object is accelerating while moving in the opposite direction (1)<br><br><u>Example of calculation</u><br>$a = \frac{14\ \text{m s}^{-1} - 0}{9} = 1.56\ \text{m s}^{-2}$ | 3 |
| | **Total for question** | **3** |

**Q7.**

| Question Number | Answer | | Mark |
|---|---|---|---|
| (a) | • Use of $v = s/t$ **Or** use of gradient | (1) | |
| | • $v = (\pm)\ 1.1$ to $1.2\ (\text{m s}^{-1})$ | (1) | |
| | • Scaling of the velocity axis so that the graph covers at least 50% of the paper above and below the axes. (A minimum of 1 number on each axis required e.g. 1 and –1) | (1) | |
| | • A positive constant velocity from 0 to 42 s and the same negative constant velocity from 48 s to 90 s with connecting line/curve (tolerance of ± 1 s) | (1) | 4 |

<u>Example of calculation</u>

Initial velocity $= \frac{46\text{ m}}{40\text{ s}} = 1.15\text{ m s}^{-1}$

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|---|---|---|---|
| (b)(i) | The graph should be a curve initially | (1) | |
| | with a decreasing gradient up to 15 m (by eye) (ignore any part of the graph above 15 m) | (1) | 2 |

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|---|---|---|---|
| (b)(ii) | 1 mark for a simplification | (1) | |
| | 1 mark for a corresponding explanation | (1) | 2 |

| Simplification | Explanation |
|---|---|
| Velocity constant **Or** velocity doesn't change **Or** velocity is an average **Or** no regions of acceleration/deceleration | • Variation in velocity during each stroke • The force applied to the swimmer/water varies (within the stroke) • As the swimmer moves above/below water to breathe, the velocity changes • The speed would change as they went from gliding to swimming |
| The velocity of the swimmer has the same magnitude in both parts of the race | The swimmer may have tired and this could be less for the second half of the race |
| The initial velocity after the turn would be greater | The swimmer would probably glide (underwater) after the turn |
| Gradient should initially increase from zero | Swimmer initially pushes off from starting block/turn |

Treat references to drag as neutral.

| | **Total for question** | 8 |
|---|---|---|