Solutions

Section A: Multiple-choice questions

Example 1 1983 Question 5, 66%

Constant non-zero acceleration means that the velocity – time graph is an oblique straight line.

∴ **A and D (ANS)**

Example 2 1978 Question 2, 81%

At t = 10s, the gradient (acceleration) decreases but the velocity continues to increase.

∴ **B (ANS)**

Example 3 2002 Question 3, 70%

Best graph is B because it matches the one I used in the previous question. Also it is the only one which has two fixed gradients, corresponding to the two sections of constant acceleration.

∴ **B (ANS)**

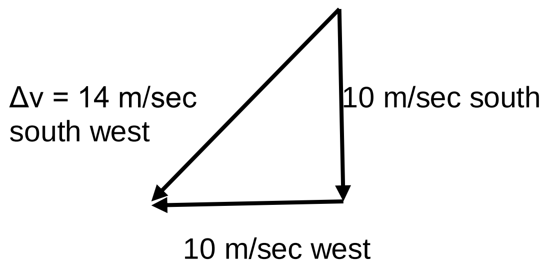
Example 4 2002 Question 4, 45%

Best graph is E because it needs to always increasing, since the car is moving over a distance of 400m. Also it is the only one that is always curved, corresponding to the two sections of constant acceleration

∴ **E (ANS)**

Example 5 1967 Question 1, 54%

The change in velocity is always given by
final – initial
∴ **10 m/sec south – 10 m/sec east.**
∴ **10 m/sec south + 10 m/sec west**



∴ **D (ANS)**

Example 6 1980 Question 2, 81%

Since both the stone and the marble will both have the same acceleration, the gradient of the graphs must be the same.
∴ Either A, C, D, E
The marble starts after the stone, so it must be either C or E.
The marble starts at v = 8.0 ms^{-1},
∴ **it must be graph C (ANS)**

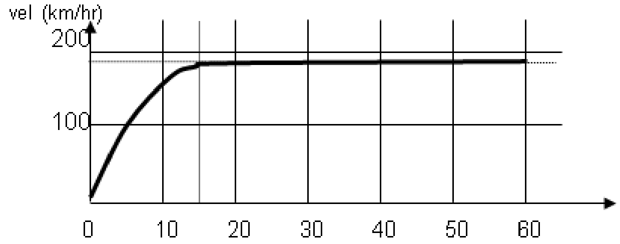
Section B: Short-answer and extended-answer questions

Example 7 1998 Question 1, 74%

To convert from km/hr to m/s you need to divide by 3.6. (This should be on your cheat sheet)
∴ 190 ÷ 3.6 = 52.8 m/s

∴53 m/s (ANS)

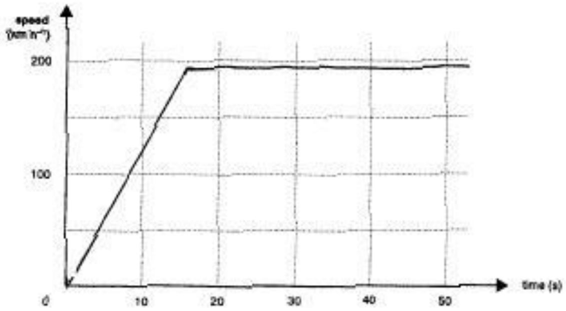
Example 8 1998 Question 2, 70%



In order to get full marks your graph had to show:

- that the terminal velocity was reached after 15 sec
- the velocity increased from 0 to 190 km/hr in the first 15 secs
- that there was a smooth transition from acceleration to a terminal velocity where the acceleration was zero.

Examiner's comment
The 3 available marks were allocated as follows:
• 1 mark for the terminal velocity section after 15 s.
• 1 mark for a velocity increase from zero to 190 km h^{-1} between 0–15 s.
• 1 mark for a graph that shows a smooth transition from increasing velocity to terminal velocity.
The average mark for this question was 2.1/3, with the main error being a failure to recognise the smooth transition, resulting in a graph as shown below. Such an answer scored only 2 marks.



Example 9 1983 Question 1, 71%

The average speed is always given by $\frac{\text{distance travelled}}{\text{time taken}}$.

In this case it is $\frac{\text{area under the graph}}{\text{time taken}} = \frac{\frac{1}{2}\times 0.5\times 2 + 2\times 1.5 + \frac{1}{2}\times 1\times 2}{3}$

$= \frac{4.5}{3}$

= 1.5 ms^{-1} (ANS)

Example 10 1983 Question 2, 64%

The distance from the starting point is called the displacement. Therefore, this answer requires you to consider vectors, so the direction of travel is important. In the first 3 seconds the object travels 4.5 m in one direction. From 3.5 (sec) to 9.0 (sec) it travels $\frac{1}{2}\times 1.0\times 1 + 1\times 3.5 + \frac{1}{2}\times 1\times 1$ = 4.5 m in the opposite direction.

$\therefore$ **after 9 (sec) the net displacement is zero.**

Example 11 1983 Question 3, 71%

The acceleration is given by the gradient of the velocity – time graph. In this case the gradient is positive, and its value is $\frac{1}{1}$ = 1. $\therefore$ **+1 ms^{-2} (ANS)**

Example 122 2000 Question 1, 75%

The distance travelled was 400m, and it took 16.0 seconds. The initial speed was 0 m/s. You need to find the acceleration.

This is given by substituting into the equation

$x = ut + ½at^2$.

$400 = 0 \times 16 + ½ \times a \times 16^2$

$\therefore 400 = 128 \times a$

$\therefore a = \frac{400}{128}$

$\therefore$ **a = 3.125 ms^{-2}** **(ANS)**

Example 133 1980 Question 1, 93%

The time it takes for the stone to reach the ground is given by $x = ut + ½at^2$
In this case u = 0, a = 10 and x = 20.

$\therefore$ 20 = ½ × 10 × t^2
$\therefore$ 20 = 5 × t^2
$\therefore$ 4 = t^2
$\therefore$ t = 2.

$\therefore$The stone take 2 secs to reach the ground (ANS)

Example 144 1980 Question 3, 11%

For the marble to pass the stone, it must catch up with the stone. You need to equate two equations of motion and solve for time (t).
If you let the marble start at time t = 0, then the time for the stone needs to be t – 0.6. This is because it will have travelled for less time than the marble.

Stone
$x = ut + ½at^2$
becomes $x = 0 \times t + ½ \times 10 \times t^2$
$\therefore x = 5t^2$
Marble
$x = ut + ½at^2$
becomes $x = 8 \times (t – 0.6) + ½ \times 10 \times (t – 0.6)^2$
$\therefore x = 8(t – 0.6) + 5(t – 0.6)^2$

For the marble to pass the stone both equations must be equal.

$\therefore 5t^2 = 8(t – 0.6) + 5(t – 0.6)^2$
$\therefore 5t^2 = 8t – 4.8 + 5(t^2 – 1.2t + 0.36)$
$\therefore 5t^2 = 8t – 4.8 + 5t^2 – 6t + 1.8$
$\therefore 0 = 2t – 3$
$\therefore 2t = 3$
$\therefore$ t = 1.5 secs(ANS)

Example 155 1978 Question 1, 63%

The average acceleration is given by $\frac{\text{change in velocity}}{\text{time taken}} = \frac{100/3.6}{15}$

= 1.85 m s^{-2} (ANS)

Example 166 1978 Question 3, 44%

The distance travelled by the two vehicles needs to be the same.
Acceleration of the motorcycle during first 10 seconds $a = \frac{80/3.6}{10} = 2.22\ m\ s^{-2}$
For the motorcycle the distance travelled in the first 10 seconds

$d = \frac{at^2}{2} = \frac{2.22\times100}{2} = 111\ m$

In the next 5 seconds $a = \frac{\frac{100}{3.6} - 80/3.6}{5} = 1.11\ m\ s^{-2}$ $d = ut + \frac{at^2}{2} = \frac{80}{3.6} \times 5 + \frac{1.11\times5^2}{2} = 125\ m$
Total distance= 236m.
During the first 15 secs, the car travels
80/3.6 × 15 = 333.3 m.
So at time t = 15, the car is 97.3 m in front of the motorcycle.
After that equation of the motion of the car $x = 97.3 + 22.2t$
Equation of the motion of the motorcycle $x = 27.8t$
Equate their positions $97.3 + 22.2t = 27.8t$ $t = 17.4\ s$
Total time=15+17.4= 32.4 seconds (ANS)

Example 177 2001 Question 12, 80%

To convert from km/hr to m/s you need to divide by 3.6. (This should be on your cheat sheet)

$\therefore$ 100 km/hr = 27.8 m/s.

$\therefore$ Δv = 27.8 m/s.

$$acc = \frac{\Delta v}{\Delta t} = \frac{27.8}{5.9}$$

= 4.71 ms^{-2} (ANS)

Example 18 2001 Question 13, 70%

Distance travelled $\rightarrow$

$x = ut + \frac{1}{2}at^2$

$\therefore x = 0 + \frac{1}{2} \times 4.71 \times 5.9^2$

= 81.9 m

= 82m (ANS)

Example 19 2002 Question 1, 76%

Distance travelled

$x = ut + \frac{1}{2}at^2$

Given u = 0, x = 400 and t = 19

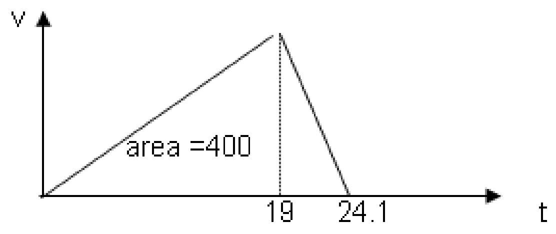
$$\therefore a = \frac{2x}{t^2}$$

$$= \frac{800}{361}$$

= 2.22 ms^{-2} (ANS)

Example 20 2002 Question 2, 40%

Average speed = total distance/total time. Use a velocity-time graph sketch



Left hand triangle has an area of 400 [displacement]
Right hand triangle has same height, but base of 5.1 instead of 19 [stopped in 5.1, accelerated for 19]
Thus area is (400 x 5.1)/19
Total area = total distance
= (24.1 x 400)/19
Average speed = distance / time
= [(24.1 x 400)/19]/24.1
= 400/19
= 21.1 ms^{-1} (ANS)

Example 21 2004 Question 2, 62%

108 km/h = 30 m/s   72 km/h = 20 m/s

$v^2 = u^2 + 2as \quad 30^2 = 20^2 + 2 \times 1.2s$

s = 208.3 m (ANS)

Example 22 2003 Question 1, 63%

The distance is the area under the graph over the first 4.0 seconds of the motion.

First second – area of the triangle $\frac{1}{2} \times 1 \times 20 = 10\ m$

Next 3 seconds – area of the trapezium $\frac{20+50}{2} \times 3 = 105\ m$

Total **115 m (ANS)**

Example 23 2003 Question 2, 62%

The acceleration is the gradient of the speed-time graph at t = 3.0 s.

$$a = \frac{50 - 20}{3}$$

a = 10 ms^{-2} (ANS)

Example 24 2003 Question 3, 48%

The average speed is the total distance divided by the time. The total distance involved calculating the total area under the graph for the 12 seconds of the motion.

From 4 to 9 seconds $\frac{50+70}{2} \times 5 = 300\ m$

Last 3 seconds 70x3=210 m

Total distance 615 m.

$v = \frac{615}{12} = \mathbf{52.1\ m\ s^{-1}}$ (ANS)

Example 25 2003 Question 4, 53%

Time taken by car B $s = \frac{u+v}{2}t \quad 400 = \frac{80/3.6}{2}t \quad t = 36\ s$

Distance travelled by car A $s = \frac{80}{3.6} \times 36 = \mathbf{800\ m}$ (ANS)

Example 26 2003 Question 5, 80%

Answer: C