Physics Factsheet

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Why Students Lose Marks: AS Motion Questions

This Factsheet analyses students' real answers to exam questions on motion in a straight line. By the end of this Factsheet, you should be more confident about:
- What the examiners want
- The kinds of things you are likely to be asked
- Common mistakes and misunderstandings

As you read the students' answers to the questions and the comments, try to work out what the student should have done - using the hints and comments if necessary - before you read the markscheme.

What do you have to know?

In this type of question, the examiner is trying to assess whether you can:
- understand the distinction between vector and scalar quantities (displacement vs distance and velocity vs speed)
- use the equations of motion
- draw, interpret and do calculations using graphs representing motion (displacement-time and velocity-time graphs)

In any question involving **calculation**, there are likely to be marks available for showing a clear **method.** If you have to use one answer in the next part of the question, there are likely to be "error carried forward" marks available - so you are only penalised once for a wrong answer.

Sally kicks a ball along the ground at a wall 3.0 m away. The ball strikes the wall at right angles, with a velocity of $6.0ms^{-1}$ and rebounds in the opposite direction with an initial velocity of $4.5ms^{-1}$. Sally stays in the same place, and stops the ball when it returns to her.

(a) Explain why the final displacement of the ball is not 6.0 m.

it's ended up in the same place it started

✓ *Mark awarded - just! - as the student has shown s/he knows what displacement means. But it would have been better to also explain that displacement is a vector so moving 3.0m forwards and 3.0m backwards results in a displacement of 0.*

[1]

(b) Explain why the average velocity of the ball is different from its average speed.

it isn't always moving in the same direction ✓✗

One of the two marks awarded - student should have realised this was insufficient for 2 marks. The examiner is looking to see that you know what average velocity and average speed are - so explaining how each is calculated would have been useful

[2]

(c) The ball is in contact with the ball for 0.15 seconds. Calculate its average acceleration during this period

$$\text{acceleration} = \frac{\text{change in speed}}{\text{time}}$$ ✗

*acceleration is the change in **velocity**, not speed. That means the direction is important - the change from 6.0 ms^{-1} forward to $4.5ms^{-1}$ backwards is a change of $10.5ms^{-1}$, not $1.5ms^{-1}$*

$$= \frac{1.5}{0.15}$$

acceleration = 10 ms^{-2} ✓*ecf. The incorrect value for change in velocity has been used correctly to calculate an acceleration*

[2]

Hints and Comments

- *On "wordy" questions, use the number of marks to help you judge how much to write - for two marks, you must make two points*
- *In part (c), if the student had not shown working, it would not have been possible to award the "error carried forward" (ecf) mark - even if the examiner had guessed what the student had done.*
- *Questions involving distinctions between speed/velocity and distance/displacement are likely to involve calculations where you must take the direction into account. One way to do this is to put forward velocities as positive and backward ones as negative*

Markscheme

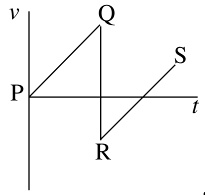
(a) displacement is a vector/ ball travels in opposite directions (1)

(b) velocity is rate of change of displacement (1) but speed is rate of change of distance (1)
or velocity is a vector/ speed is a scalar (1) and the velocity changes direction (1)

(c) change in velocity = -4.5 - 6 = $-10.5ms^{-1}$ (1)
acceleration = -10.5/0.15 = -70 ms^{-2} (1) *ecf*

Now try marking this student answer before you look at the markscheme and comments.

The graph below shows the variation of velocity with time for a vertically bouncing ball. The ball is released above the ground at P.



(a) What happens at point Q? *Velocity changes from positive to negative* .... [1]

(b) The gradients of lines PQ and RS are the same. Explain why.

The speed is the same from P to Q and from R to S .... [2]

(c) What is represented by the area between line PQ and the time axis?

distance .... [2]

(d) The ball is dropped from a height of 0.80m. Calculate its speed immediately before impact (*assume $g = 9.8\ ms^{-2}$*)

$2as = v^2 - u^2$ $20 \times 0.8 = v^{-1}$ $v = 4\ ms^{-1}$ .... [2]

Here's the markscheme:

(a) The ball hits the floor (1)

(b) The gradient represents acceleration (1) which is constant because it is the acceleration due to gravity (1)

(c) height/distance/displacement (1) of the ball above the ground when it is dropped (1)

(d) $v^2 = 2 \times 9.8 \times 0.8 = 15.68$ (1)
$v = 4.0\ ms^{-1}$

So how did the student score?

(a) *Velocity changes from positive to negative* 0/1 - although this is true, "what happens" refers to something physical that you would observe - so you have to refer to the ball changing direction - or better (read the question!) bouncing

(b) *The speed is the same from P to Q and from R to S* 0/2 -the student appears to have confused this with a displacement graph (where the gradient would correspond to the velocity)

(c) *distance* 1/2 - correct, but not specific enough about **which** distance. The student has not used the fact that the line PQ is mentioned - the answer given is a general answer to what is represented by the area under a velocity-time graph

(d) *$2as = v^2 - u^2$ $20 \times 0.8 = v^2$ $v = 4\ ms^{-1}$* 1/2 - correct method, but the candidate has not used the value of g given in the question.

A car accelerates uniformly from a speed of 5.0 ms^{-1} to a speed of 13 ms^{-1} in 4.0 seconds.

(a) Calculate its acceleration

(13 - 5)/4 = 2 ✓ ✗ A correct calculation, but the student has omitted the units, and despite all the original data being given to 2 SF, has only quoted 1 SF in the answer .... [2]

(b) Calculate the distance it travels in this time

9×4 = 36m ✓ ✓ Both marks awarded - but this was a risky strategy, is it is not clear what the "9×4" refers to without a formula being quoted (average speed ×time = distance, in this case) .... [2]

(c) Explain why the word "uniformly" in the question is important

couldn't use the equations otherwise ✗ Although this is true, the student has not explained fully enough - or demonstrated an understanding of the word "uniformly" .... [1]

Hints and Comments

- *Always make it clear which formula you are using to ensure you get method marks*
- *It does matter whether you write 2 ms^{-2} or 2.0 ms^{-2} - the zero shows it is accurate to 2 SF. That's why questions write it like this.*

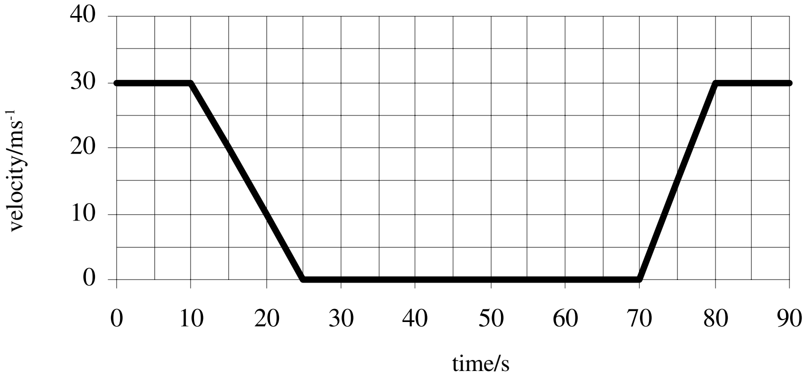
Markscheme

(a) a = (13 - 5)/4 (1) a = 2.0 ms^{-2} (1)

(b) Using $2as = v^2 - u^2$ or $s = ut + \frac{1}{2}at^2$ or $s = \frac{1}{2}(u + v)t$ (1)
36m (1)

(c) This means constant acceleration - which is required for the use of the standard equations (1)

The diagram shows a velocity-time graph for a car that stops at traffic lights then moves away.



(a) Use the graph to show that the car travels 225m while it is decelerating

½ (30)(15) = 225m ✗✓ *The question indicated that the graph had to be used - the candidate has shown no evidence of this. One mark awarded for correct calculation* [2]

(b) Calculate the acceleration of the car after it moves away

30/10 = 3 ✓✗ *Correct calculation and answer, but no units* [2]

(c) The velocity of a second car is measured over the same period of time.
Its initial velocity is 40 ms^{-1}, which it maintains for 10 seconds. It then decelerates uniformly to rest at $4ms^{-2}$.
It remains at rest for 40 seconds, then accelerates uniformly to a velocity of $30ms^{-1}$ while it covers the next 300m.
It then maintains a constant velocity of 30 ms^{-1} during the rest of the time for which it is observed.

(i) Calculate the time for which the car is decelerating

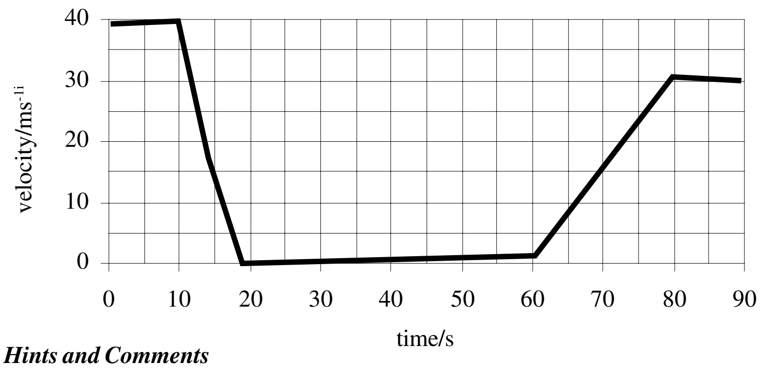
10 s ✓ *Correct - but why no working? When a "calculation" is asked for, working is expected* [1]

(ii) Calculate the time for which the car is accelerating after being at rest

$300 = ½at^2$ $600 = at^2$ ✓✓ *Full marks here - but this is a very hard method! Perhaps the candidate had not remembered the equation s = ½ (u + v)t, which would have given the answer much more easily*

$30 = at$ $30 \times t = 600$ $t = 20$ [2]

(iii) Draw the velocity time graph for this car on the axes below. [2]



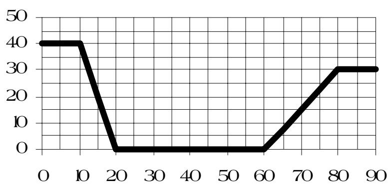
✗✓ *The candidate clearly understood what was required, but has lost a mark through sloppy drawing - the parts that should be horizontal do not appear to be so, the times are not exact and one of the lines looks more like a curve.*

Hints and Comments

- *If you are asked to "show that", you need to be extra careful to show working. If you are told to use a graph, make sure you either show working on the graph (eg marking a triangle) or state how you are using it (eg area under graph = distance)*
- *You may find it helpful to write out all the equations of motion before starting a question - then it is easier to choose the appropriate one*
- *Graphs do have to be drawn accurately - use a ruler where appropriate, and make curves smooth. "Fudging" it if you are not sure of the exact point will definitely not get you the mark.*

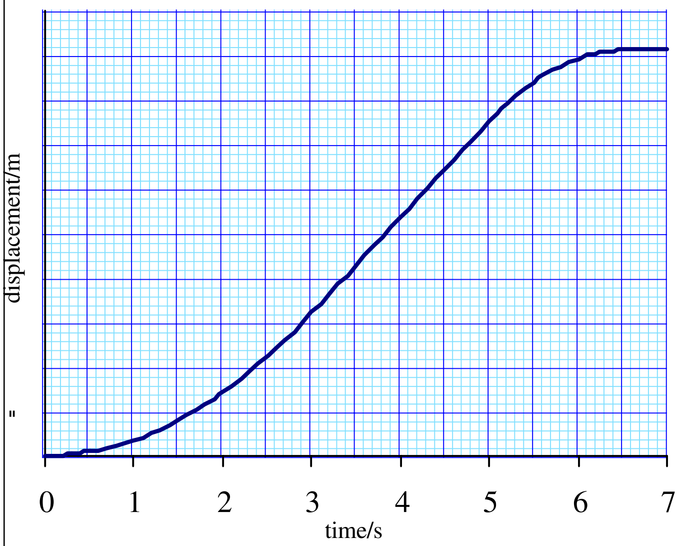
Markscheme

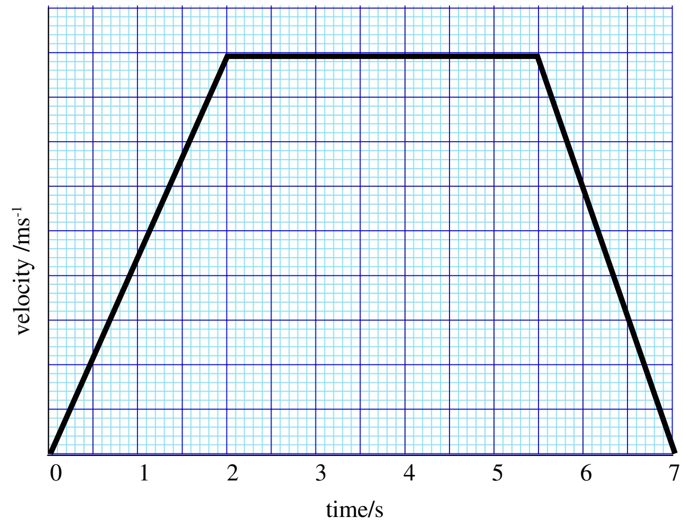
(a) Area under graph = displacement or evidence of using graph (1)
$½ \times 30 \times 15 = 225m$ (1)
(b) 30/10 (1) = $3ms^{-2}$ (1)
(c) (i) 40/t = 4 t = 10 s (1)
(ii) 300 =½ (0 + 30)t (1) t = 20s (1)
(iii) Correct shape (1) Points plotted correctly (allow e.c.f. from above)



Now try marking this student answer before looking at the markscheme.

Jaz is running along a straight track. The graph below on the left shows how his displacement varies with time. Without calculation, sketch on the graph paper on the right how his velocity varies with time. [4]



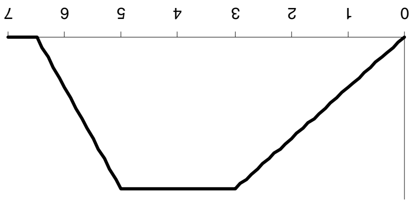


Hints and Comments

- *If the displacement-time graph looks like part of a* ***quadratic*** *curve, that means the velocity is increasing linearly.*
  If the displacement-time graph is a straight line, the velocity is constant
  If the displacement-time graph is horizontal, the velocity is zero.
- *Always look out for key points in time when the motion changes, and line them up*

Markscheme

(linear) increase to t ≈ 3 (1)
constant velocity from t≈ 3 to t ≈ 5 (1)
(linear) decrease from t≈ 5 to t ≈ 6.5 (1)
zero velocity from t ≈ 6.5 onwards (1)



So how did the student score?

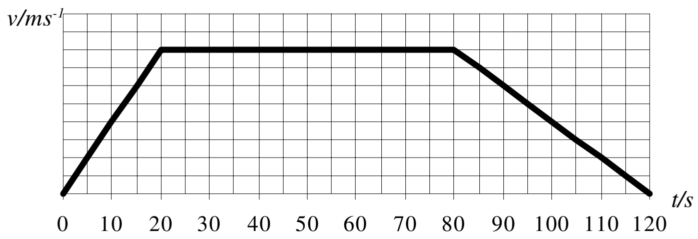
Although the graph is broadly the right shape and looks similar to the markscheme, the student omitted the zero velocity part altogether - and the times were too inexact to score any of the other marks. So 0/4.

Questions

1. A car accelerates uniformly from rest for 10 seconds. In that time it covers 200m. Calculate its acceleration. [2]

2. Explain how it is possible to travel with constant speed, but varying velocity. [2]

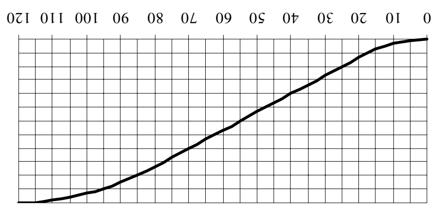
3. The diagram below shows a velocity-time graph for a runner. Without doing calculations, sketch the displacement-time graph [1]



4. Explain how the graph in question 3 could be used to calculate
   (i) the distance covered by the runner [1]
   (ii) the acceleration and deceleration of the runner [1]

Answers

1. $s = \frac{1}{2}at^2$ $200 = \frac{1}{2}a(100)$ (1)
   $a = 4\text{ms}^{-2}$ (1)
2. Velocity is a vector/velocity includes a direction (1)
   So you could change direction but not speed (eg move in a circle) (1)
3. quadratic increase from 0 to 20 (1)
   straight line increase 20 to 80 (1)
   rate of increase slows (quadratic again) from 80 to 120 (1)



4. (i) Area between graph and time-axis
   (ii) Gradient of the graph

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