LONDON SCIENCE COLLEGE

MARK SCHEME

PHYSICS

AS-Level

GRAPHS FOR MOTION

TEST 1

1 (a) Both t_m values correct: 0.404, 0.429
AND
Both t_m^2 values correct: 0.163, 0.184 ✓

Exact values required for the mark.

1

(b) Both plotted points to nearest mm ✓
Best line of fit to points ✓

The line should be a straight line with approximately an equal number of points on either side of the line.

2

(c) Large triangle drawn (at least 8 cm × 8 cm) ✓
Correct values read from graph ✓
Gradient value in range 0.190 to 0.222 ✓

Allow 2 or 3 sf for gradient

3

(d) g = 9.71 (ms^{-2}) or correct value from gradient value in **(c)** ✓.

(The answer must be in the range 9.0 to 10.5 (ms^{-2})).

Allow 2 or 3 sf.

Unit not required

1

(e) $$\% \ difference = \frac{(9.81 - 9.71)}{9.81} \times 100 \ = 1.02$$

OR correct computation using value from **(d)** ✓

If the candidate's value is exactly 9.81, then a statement that there is no (or zero) percentage difference is acceptable.

No sf penalty.

NB. Allow an answer from a calculation with either the candidate's value or the accepted value as the denominator in the equation.

1

(f) 0.001 s✓ (half the spread)
(Must have unit).

1

(g) $g = 2s/t_m^2$ ✓
= 2 × 0.300/0.245^2 ✓
= 10.0 (or 10.00) ms^{-2} ✓

Unit required and 3 or 4sf for the last mark.

3

(h) % uncertainty in s = 0.33 **and**
% uncertainty in t_m = 0.41 ✓

*Allow ecf from part **(f)**.*

% uncertainty in g
= 0.33 + (2 × 0.41) = 1.15 ✓

Allow ecf at each stage of calculation.

Uncertainty in g
= 10.0 × 1.15/100 = 0.12 m s^{-2} or 0.1 m s^{-2} ✓

*Allow ecf from part **(g)**.*

(allow 1 or 2 sf only)
(Must have unit for 3rd mark).

3

(i) (a) Use spherical objects of different mass **and** determine mass with balance ✓

Annotate the script with the appropriate letter at the point where the mark has been achieved.

(b) Would need **same diameter** spherical objects for fair comparison (same air resistance etc) ✓

(c) Time spherical object falling through same height **and** compare times

*Alternative for **(c)**:*
i.e. repeat whole of experiment, plot extracted values of g against mass. Horizontal line expected, concluding acceleration same for different masses.

3

[18]

2 B

[1]

3 A

[1]

4 (a) (i) Attempt to determine area under curve
Number of “large” squares (22 ± 1)
or distance per square = 20 (large) or 0.8 (small)
435 ± 10 (m)

Zero marks for use of suvat

3

(ii) Tangent to curve seen drawn at 10 s
Gradient of tangent = 4.2 (allow 3.5 – 4.5) (m s^{-2})

Zero marks for use of suvat

2

(iii) 640 × 4 or 2560 or 640 × their 7aii
5800-2560 or 5800-(640 × their 7aii)
3200 (3240) (N)

3

(iv) 89 (read off from graph) cnao
520 (516) (kW)

If answer is in W, then unit must be given

2

(b) The marking scheme for this question includes an overall assessment for the quality of written communication (QWC). There are no discrete marks for the assessment of QWC but the candidate's QWC in this answer will be one of the criteria used to assign a level and award the marks for this question.

Descriptor – an answer will be expected to meet most of the criteria in the level descriptor.

Level 3 – good
-claims supported by an appropriate range of evidence;
-good use of information or ideas about physics, going beyond those given in the question;
-argument is well structured with minimal repetition or irrelevant points;
-accurate and clear expression of ideas with only minor errors of grammar, punctuation and spelling.
Level 2 – modest
-claims partly supported by evidence;
-good use of information or ideas about physics given in the question but limited beyond this;
-the argument shows some attempt at structure;
-the ideas are expressed with reasonable clarity but with a few errors of grammar, punctuation and spelling.
Level 1 – limited
-valid points but not clearly linked to an argument structure;
-limited use of information about physics;
-unstructured;
-errors in spelling, punctuation and grammar or lack of fluency.
Level 0
-incorrect, inappropriate or no response.

Allow named resistive forces e.g. air resistance, drag, friction.

Allow thrust for driving force.

Explanation of velocity variation:

Car accelerates / Velocity increases because driving force is larger than resistive forces

Maximum acceleration at start

Resistive forces are zero at start

Resistive forces increase with increasing velocity

Drag proportional to velocity-squared

Resultant force decreases with increasing velocity

Acceleration decreases with increasing velocity

Terminal velocity reached when resultant force is zero / resistive forces balance the driving force

Explanation of change with DRS in use:

Resistive forces reduced (because air resistance / drag) is reduced

Resultant force is non-zero for longer time

Acceleration occurs over longer time

Terminal velocity reached in longer time

Higher terminal velocity achieved

Higher maximum velocity on graph

Same initial acceleration / gradient on graph

6

[16]

5 (a) Velocity and speed correct ✓
Distance and displacement correct ✓

	velocity	speed	distance	displacement
vector	✓			✓
scalar		✓	✓	

2

(b) (i) $v^2 = u^2 + 2as$

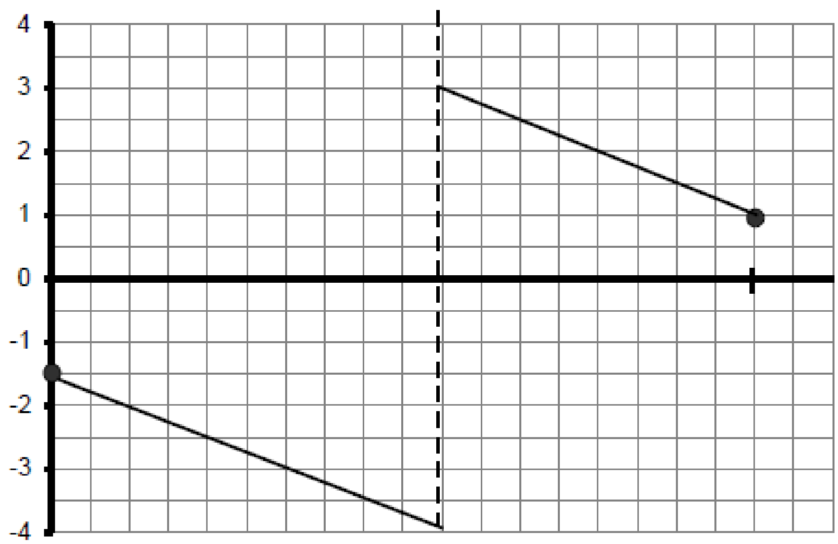
$v = \sqrt{u^2 + 2as}$ ✓ $\quad$ $v = \sqrt{1.5^2 + 2 \times 9.81 \times 0.65}$ ✓

= (−)3.9 (m s^{-1}) ✓two or more sig fig needed (− 3.87337 m s^{-1})

1st mark for equation rearranged to make v the subject (note sq' root may be implied by a later calculation) penalise the use of g = 10 m s^2 only on this question
2nd mark for substituting numbers into any valid equation
3rd mark for answer
Alt' approach is gainKE = lossPE
missing out u gives zero marks
answer only gains one mark [Note it is possible to achieve the correct answer by a wrong calculation]

3

(ii) **velocity / ms^{-1}**



first line descends from X to the dotted line at t_A or up to one division sooner ✓ (allow line to curve)

first line is straight and descends from X to $v = -4$ (m s^{-1}) ✓(allow tolerance one division)
second line has same gradient as the first, straight and descends to v = 1(m s^{-1}) ✓(tolerance ½ division)
a steep line may join the two straight lines but its width must be less than 2 divisions

3

(c) $s = ut + 1/2at^2$

t = $\sqrt{\frac{2s}{a}}$ OR correct substitution seen into either equation t = $\sqrt{\frac{2 \times 1.2}{9.81}}$ ✓

= 0.49 (s) ✓ (0.4946 s)

working must be shown for the first mark but not the subsequent marks

$v = s / t$

= 5.0 / 0.49 = 10 (m s^{-1}) ✓ (10.2 m s^{-1}) (allow CE from their time)

[note it is possible to achieve the correct answer by a wrong calculation]

3

[11]

6 (a) *GPE* to *KE* to *GPE* ✓

no energy lost (from system) / no work done against resistive forces ✓

initial *GPE* = final (*GPE*) / initial (*GPE*) = final *GPE*

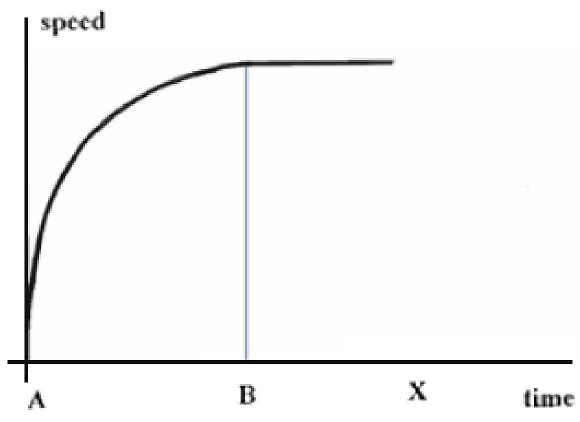
OR *h* = *GPE /mg* and these are all constant so *h* is the same ✓

3

(b) Initial curve with decreasing gradient and reaching constant maximum speed before X and maintaining constant speed up to X ✓

B labelled in correct place ✓

B labelled in correct place **AND** constant speed maintained for remainder of candidates graph and line is straight ✓



3

(c) (first law) ball travels in a straight line at a constant speed / constant velocity / (maintains) uniform / no change in motion / zero acceleration ✓

there is no (external) **unbalanced / resultant** force acting on it ✓

2

[8]

7 C

[1]

8 clear attempt to use area under graph/statement that distance is equivalent to area under graph

C1

38 to 40 squares/1 square is equivalent to 0.05 m

C1

1.9 to 2.0 m

A1

[3]

9 (a) the sprinter takes time to react to the starting pistol **(1)**

B1

1

(b) attempt using tangent **(1)**

C1

acceleration about 0.74 (0.68 – 0.80) **(1)**

A1

m s^{-2} **(1)**

B1

3

(c) appreciation that area under the graph **(1)**

C1

distance per square = 1m **(1)** or clear use of scale in correct approach

C1

total squares =10 – 10.8 **(1)**

C1

distance correct 10.1 – 10.6m **(1)** (unit essential)

A1

4

or alternative method using triangle and trapezium

(d) use a velocity sensor **or** record time to reach set distances **(1)**

M1

detail about frequency at which data is collected **(1)**

sensor placed so that athlete runs toward it

plot distance time graph and measure gradient at different times

A1

2

[10]

10 (a) (i) use of appropriate data from graph **(1)**

answer in acceptable range (to be decided) **(1)**

(ii) zero at 0, 0.2 0.58, 0.8 and 1 s (approx) **(1)**

reasonable attempt to show relative magnitudes **(1)**

4

(b) appreciation of area under the graph **(1)**

appropriate counting of squares **(1)**

distance per square **(1)**

correct answer in acceptable range **(1)**

4

[8]

Examiner reports

1

(a) Correctly answered by almost all candidates.

(b) As usual in this question a small proportion of candidates failed to accurately plot both points and an even greater proportion were unable to draw an acceptable line of best fit.

(c) Less marks were lost on this question than in previous years, most likely because these were mostly A2 candidates re-sitting the paper. Most candidates were able to calculate a gradient value within the allowed range.

(d) This was straightforward for nearly all candidates.

(e) A familiar question, well answered by most candidates.

Parts **(f)**, **(g)** and **(h)** discriminated well, with only the most able candidates scoring five marks or more.

(f) The easiest part of the question, requiring use of 'uncertainty = 0.5 × range'

(g) Although this was considered to be straightforward, many candidates failed to score the full three marks. Common errors were incorrect substitution into the formula and missing the unit in the final answer.

(h) This was the most discriminating part of the question, with candidates often scoring no marks. The process of adding percentage uncertainties to calculate the percentage uncertainty in the calculated value of g, and then converting back to an absolute uncertainty with suitable significant figures and unit was beyond most candidates.

(i) This proved to be difficult, and only the most able candidates scored more than one mark. An easy mark was often lost by lack of reference to measuring the mass of the spheres with a balance. Many candidates failed to realise that for a fair comparison the spherical objects would need to have the same diameter so that air resistance was the same.

2

Being able to interpret graphs is another important skill commonly tested by multiple choice questions. 67% of students were able to spot that graph B correctly represented the variation of the gradient of the velocity-time graph with time. The most popular distractor was A, perhaps due to students eliminating C and D as being obviously incorrect, and being able to go no further.

3

Students should be warned about multiple-choice questions that have an apparently very straightforward solution. Approximately the same number of students gave the incorrect response B as gave the correct response in this question. Presumably they calculated the speed for the second half of the journey, and took the average of the two speeds rather than calculating the total distance divided by the total time.

4

(a) No credit was given in parts (i) or (ii) for using suvat equations, as the acceleration is not constant. Evidence of "counting squares" for part (i) and a tangent for part (ii) were expected to be seen. A majority of students comfortably coped with parts (iii) and (iv).

(b) Students found this question very accessible, with just over 50% gaining at least four marks. Answers of the highest quality showed a detailed understanding of the effect of the DRS on the duration of the acceleration. A common misconception was that the initial acceleration would be greater and therefore the start of the graph would be steeper.

5 The equations of motion were generally understood well by most students. Problems started to emerge when it came to the graphical work in the question. The calculation in part (b)(i) was performed well but some weaker students lost marks by choosing to use the valid idea that the gain in kinetic energy is equal to the loss of potential energy but then forgot to note that the initial kinetic energy is not equal to zero. Others lost marks when they rounded v = 3.87 m s^{-1} to 3.8 m s^{-1}.

A majority of students found sketching the graph in (b)(ii) quite difficult. Even the top grade students were only confident about the first straight line drawn from X down to a time t_A. Further along the graph was drawn with random variations by most and the better students were not very careful to make the second line parallel to the first.

In (c) a majority could tackle the question in full. The weaker students did not know how to separate the vertical and horizontal components and connect them through the time of flight. Some students who did manage the first part of the calculation did not appreciate that the horizontal velocity was constant and took its initial value to be zero.

6 The answers to part (a) were generally very detailed with many students continuing to write to the bottom of the page. Answers could have been more succinct perhaps. eg *No energy lost, so all* GPE at A *is converted to KE at B which is converted to back to an equal amount of GPE* at C. Some students explained that GPE transfers to KE but then failed to mention the conversion back to GPE. eg 'all the GPE is converted to KE at B, so it gets to the same height at C'. Often the law of energy conservation was quoted but they did not explicitly state that there were no energy 'losses' due to no friction or drag.

In part (b) there was some carelessness in the positioning of the label for B. Many students had a significant straight section at the start and showed the ball decelerating after point X.

In part (c) students often stated that the speed was constant but did not point out that the ball would move in a straight line. They often explained the motion in terms of there being 'no forces' acting on the ball rather than 'balanced forces'.

7 This question was an easy starter that required the application of "change of momentum = area under force/time graph". This question discriminated well, and just over two-thirds of the students gave the correct answer. The most popular incorrect response was distractor D, no doubt because the students who chose it overlooked the factor of ½ when calculating a triangular area.

8 Most candidates realised that they should determine the area under the graph. Techniques for doing this varied, but square counting tended to be most accurate and less prone to error. The standard of setting out of working was generally poor.

9 In part (a), some simply stated that the sprinter did not start at the time the gun was fired but gave no reason for this. A mention of reaction time or thinking time was required.

Part (b) was answered well. The majority of the candidates appreciated that a tangent at 3.5 s was needed and many did this accurately. The unit was well known.

Although many appreciated that the area under the graph was needed in part (c), relatively few could convert this knowledge into an accurate distance. Some treated the area as a triangle and some tried applying an equation of uniform accelerated motion.

There were many vague and/or impracticable ideas in part (d). Comments such as use a computer or attach a speedometer to the runner were not uncommon. Some answers stated the data needed (distance and time) but not how it would be obtained or how the velocity data would be obtained from it.