LONDON SCIENCE COLLEGE

MARK SCHEME

PHYSICS

AS-Level

GRAPHS FOR MOTION

TEST 2

Mark schemes

1 (a) (i) (use of $a = \frac{\Delta v}{\Delta t}$ gives) $a = \frac{4.5}{3600}$ **(1)**

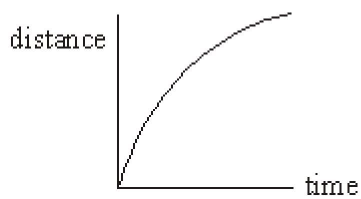
$=1.25 \times 10^{-3}\ ms^{-2}$ **(1)**

(ii) (use of $v^2 = u^2 + 2as$ gives) $0=4.5^2 - 2 \times 1.25 \times 10^{-3} \times s$ **(1)**

$s\left(= \frac{20.25}{2.5 \times 10^{-3}}\right) = 8.1 \times 10^3\ m$ **(1)**

4

(b) increasing curve **(1)**
correct curve **(1)**



1

(c) gradient (slope) of graph represents speed **(1)**
hence graph has decreasing gradient **(1)**

2

[8]

2 (a) scales **(1)**

six points correctly plotted **(1)**

trendline **(1)**

3

(b) average acceleration = $\frac{26}{25}$ **(1)**

$= 1.0(4)\ ms^{-2}$ (1)

(allow C.E. for incorrect values used in acceleration calculation)

2

(c) area under graph **(1)**

= 510 ± 30 m **(1)**

2

(d) (graph to show force starting from *y*-axis)

decreasing (not a straight line) **(1)**

to zero (at end of graph) **(1)**

2

(e) (since) gradient of a velocity-time graph gives acceleration **(1)**

first graph shows acceleration is decreasing **(1)**

2

[11]

3 (a) (i) car A: travels at constant speed **(1)**

(ii) car B: accelerates for first 5 secs (or up to 18 m s^{-1}) **(1)**
then travels at constant speed **(1)**

3

(b) (i) car A: distance = 5.0 × 16 **(1)**
= 80 m **(1)**

(ii) car B: (distance = area under graph)
distance = [5.0 × ½ (18 + 14)] **(1)**
= 80 m **(1)**

4

(c) car B is initially slower than car A (for first 2.5 s) **(1)**
distance apart therefore increases **(1)**
cars have same speed at 2.5 s**(1)**
after 2.5 s, car B travels faster than car A (or separation decreases) **(1)**

max 3

[10]

4 (a) (i) acceleration **(1)**

(ii) both represent acceleration of free fall
[or same acceleration] **(1)**

(iii) height/distance ball is dropped from above the ground
[or displacement] **(1)**

(iv) moving in the opposite direction **(1)**

(v) kinetic energy is lost in the collision
[or inelastic collision] **(1)**

5

(b) (i) $v^2 = 2 \times 9.81 \times 1.2$ **(1)**
$v = 4.9\ \text{m s}^{-1}$ **(1)** ($4.85\ \text{m s}^{-1}$)

(ii) $u^2 = 2 \times 9.81 \times 0.75$ **(1)**
$u = 3.8\ \text{m s}^{-1}$ **(1)** ($3.84\ \text{m s}^{-1}$)

(iii) change in momentum = $0.15 \times 3.84 - 0.15 \times 4.85$ **(1)**
$= -1.3\ \text{kg m s}^{-1}$ **(1)** ($1.25\ \text{kg m s}^{-1}$)

(allow C.E. from (b) (i) and (b)(ii))

(iv) $F = \frac{1.3}{0.10}$ **(1)**
$= 13\ \text{N}$ **(1)**

(allow C.E. from (b)(iii))

8

[13]

5 (a) AB: (uniform) acceleration **(1)**
BC: constant velocity / speed or zero acceleration **(1)**
CD: negative acceleration or deceleration or decreasing speed / velocity **(1)**
DE: stationary or zero velocity **(1)**
EF ; (uniform) acceleration in <u>opposite</u> direction **(1)**

5

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

1

(c) distance is a scalar and thus is the total area under the graph
[or the idea that the train travels in the opposite direction] **(1)**
displacement is a vector and therefore the areas cancel **(1)**

2

[8]

6 (a) vt_b: distance moved (at speed v) before brakes are applied
[or thinking / reaction distance] **(1)**

$\frac{v^2}{2a}$: distance moved while braking [or after applying brakes] **(1)**

2

(b) (i) column B: (8.9) 13.3(5) 17.8 22.2(5) 26.7 31.1(5)
(all values correct to 2 or 3 sig. figs ± 0.2) **(1)**

(ii) column D: 1.3(5) 1.72 2.02 2.39 2.73 3.08
(all values correct to 2 or 3 sig figs ± 0.1) **(1)**

2

(c) graph of $\frac{s}{v}$ against v [or v against $\frac{s}{v}$] **(1)**

axes labelled correctly **(1)** (column D vs column B or A)
appropriate scales **(1)**
at least four points plotted correctly to 1 square **(1)**
acceptable straight line **(1)**
[note: if chosen graph gives a curve (e.g. s against v) then candidate can only score 2nd, 3rd and 4th marks]

5

(d) (i) (intercept) t_b = 0.66 s **(1)** (values in range 0.6 to 0.7 accepted)

(ii) gradient = (any triangle e.g. (3 - 1) / (30 - 4.5)) = 7.8×10^{-2} (s^2m^{-1}) **(1)**
[other answers, if consistent with graph, acceptable]
gradient = (1 / 2a) **(1)**
gives a = 6.4 m s^{-2} **(1)** (values in range 6.1 to 6.7 accepted)
(allow C.E. for value of gradient)

[if column D vs column A used, gradient = 0.022
use of conversion factor gives gradient = 0.078 (s^2m^{-1})]

[if graph of v against $\frac{s}{v}$, gradient = 12.8 m s^{-2}

= 2a for first two marks]

4

[13]

7 (a) (i) **region A**: <u>uniform</u> acceleration

(or (free-fall) acceleration = g (= 9.8(i) m s^{-2}))

force acting on parachutist is entirely his weight

(or other forces are very small) **(1)**

(ii) **region B**: speed is still increasing

acceleration is decreasing **(2)** (any two)

because frictional (drag) forces become significant (at higher speeds)

(iii) **region C**: uniform speed (50 m s^{-1})

because resultant force on parachutist is zero **(2)** (any two)

weight balanced exactly by resistive force upwards

The Quality of Written Communication marks were awarded primarily for the quality of answers to this part

(6)

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(b) deceleration is gradient of the graph (at t = 13s) **(1)**

(e.g. 20/1 or 40/2) = 20 m s^{-2} **(1)**

(2)

(c) distance = area under graph **(1)**
suitable method used to determine area (e.g. counting squares) **(1)**
with a suitable scaling factor (e.g. area of each square = 5 m^2) **(1)**
distance = 335 m (±15 m) **(1)**

(4)

(d) (i) speed = $\sqrt{(5.0^2 + 3.0^2)}$ = 5.8 m s^{-1} **(1)**

(ii) $\tan\theta = \frac{3}{5}$ gives θ = 31° **(1)**

(2)

[14]

8

(a) (i) gradient = $\frac{2.1}{0.7}$ = 3.0 ms^{-2} **(1)**

(ii) distance is area under graph (to t = 0.1 s)

or $\frac{1}{2} \times 0.7 \times 2.1 \left(\frac{2.1 + 2.5}{2}\right) 0.3$ **(1)** = 1.4(2) m **(1)**

3

(b) (i) $T - mg = ma$ [or T = 1500(9.8+3.0)] **(1)**
= 1.9×10^4 N **(1)**

$T = mg$ = 1.5×10^4 N **(1)**

(ii) EF **(1)**

4

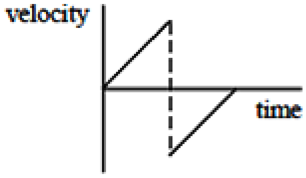
(c) power = Fv or $1.5 \times 10^4 \times 2.5$ **(1)**
= 3.7[3.8] × 10^4 W **(1)**

2

[9]

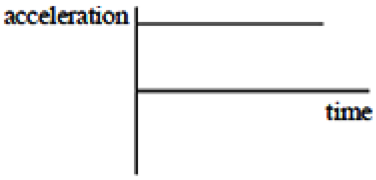
9 accept mirror image for (a) and (b)

(a)



straight line sloping up **(1)**
sudden change to negative velocity **(1)**
smaller negative velocity **(1)**
same gradient as positive line **(1)**

(b)



constant value shown **(1)**

(5)

(c) (i) vertically down at P **(1)**

(ii) vertically down at Q **(1)**

(iii) along tangent at P **(1)**

(iv) along tangent at Q **(1)**

(4)

(d) horizontal component of velocity at Q = 15 cos 50° **(1)** = 9.64 m s^{-1} **(1)**

momentum at Q = 0.15 × 9.64 = 1.45 **(1)** N s (or kg m s^{-1}) (horizontally) **(1)**

(4)

[13]

10 B

[1]

Examiner reports

1 The deceleration and distance travelled by the supertanker were calculated correctly in part (a) by a large number of candidates. The few errors that occurred were either the unit for deceleration or an incorrect conversion of hours to seconds.

Parts (b) and (c) caused more problems and many less able candidates were unable to sketch a correct graph, confusing distance-time with speed-time. The explanation of the shape of the graph generated some quite vague answers with considerable confusion over what the gradient of the graph represented.

2 For the most part this question was answered well. In part (a), a significant minority of candidates did choose inappropriate scales for the graph, but plotting errors were rare. The calculation for the average acceleration in part (b) was done well but that for the distance travelled, in part (c) was less so. Most candidates appreciated that they needed to estimate the area under the graph, but many failed to do this within the allowed range.

Parts (c) and (d) caused problems to a number of candidates because they did not understand the term *resultant force*. This was often confused with air resistance which, candidates correctly assumed, increased with speed. The mark scheme did allow candidates to score marks in part (d), even if they had misunderstood resultant force, provided their description of the effect of an increasing resistive force was correct.

3 This question proved to be very accessible and full marks were awarded frequently. The only real confusion arose in part (c) where weaker candidates had difficulty organising their thoughts and expressing them in a logical way. Loose use of language was evident, with statements such as “accelerating at a constant speed” cropping up in a significant minority of scripts.

4 Part (a) discriminated very well and although most candidates scored some marks, only the best were awarded the maximum. The two sections least well done were part (iii) which asked what the area under the line AB represented and part (v) which asked why the speed at C was less than the speed at B. In answering part (v) a significant proportion of candidates did not realise that the ball rebounded from the floor at C.

Part (b) also produced a variation of marks. Most candidates completed part (i) but found the other parts of the question more difficult. There was considerable confusion over signs and initial and final velocities in part (ii). This confusion was carried over into part (iii) and most candidates made no allowance for the change in direction of momentum but simply subtracted the magnitudes of the initial and final momenta. As in the past, the unit for momentum caused problems and penalising a unit error at this point was quite common.

5 Candidates found this question quite straightforward and full marks were not uncommon, but the idea of the magnitude of velocity increasing with negative acceleration did tax some. In part (c) a significant number of candidates did have trouble explaining clearly why the distance travelled was different to the displacement. There was a tendency to offer vague answers without focusing on the fact that displacement is a vector quantity whereas distance is scalar.

6 Part (a) was quite straightforward and the majority of candidates gained both marks, although some marks were withheld due to candidates referring carelessly to time rather than distance.

The columns of data in part (b) were usually completed correctly, but some candidates lost marks as a result of using too many or too few significant figures. Again in part (c) many candidates scored full marks but a significant minority were unable to choose appropriate scales for their chosen graph. Others were unable to plot a suitable graph, mostly as a result of plotting s against v or v against s rather than s / v against v.

Most of candidates who plotted a straight line graph knew how to determine the value of tb in part (d). Some however failed to score this mark as a result of lack of care in plotting the graph in the previous section. In part (ii) , most candidates were able to obtain a correct value for the gradient of their straight line graph. In addition, these candidates were able to relate the gradient to the acceleration and obtained a correct value for the acceleration. On the other hand, many of the weaker candidates had plotted an unsuitable graph (e.g. s vs v) and were unable to make progress with the calculations. They were clearly unaware of the necessity of choosing variables that would produce a straight line graph.

7 In part (a) most candidates were able to interpret the graph correctly and almost all understood why the parachutist reached constant terminal speed in region C of the graph. Although many also understood and stated that the acceleration in region A was constant, few stated that this was because the drag on the parachutist was negligible or much smaller than his weight. Answers were generally well expressed and a mark of four or five was most common. A minority of candidates, however, was quite incapable of using physics terms accurately and subsequently scored few marks.

Many candidates understood that the acceleration in part (b) equalled the gradient of the line in region D of the graph and arrived at a correct answer (although the unit of acceleration was often given as $^{-1}$). Candidates who used $a = (\upsilon - u) / t$ very often chose points off the straight section of the graph and arrived at α value for a outside the acceptable range.

In part (c) many candidates ignored the graph and attempted to use an equation of uniform acceleration to find the distance travelled. The majority, however, made some attempt to relate distance to the area under the graph and most of these answers fell within the acceptable range.

Part (d) was most often correct, although in part (ii) many candidates inverted the tan function and found the angle to the horizontal rather than the vertical.

8 In this high-scoring question most of the difficulties arose in part (a), where candidates were not careful enough to distinguish between the straight part of the graph. AB, where the acceleration was uniform, and the curved part, BC. where it was not. Thus, a very common wrong answer in part (a)(i) was 2.5 ms^{-2} and even those candidates who recognised that they had to find the area under the graph up to C in part (a)(ii) most commonly treated that area as a triangle, giving the answer 1 .25m. Only a small proportion of the candidates calculated the area sufficiently accurately. Other mistakes included finding the area up to t = 0.7s or up to t = 4.3 s.

Answers to part (b) were better. The main weaknesses were inadequate explanation in part (b)(i) and carelessness in part (b)(ii).