Physics Challenge 2013 Mark-scheme

Setting the paper

It is intended that the paper is taken on Friday 8th March 2013 in exam conditions. However, if this date is not possible, any date during the period 4th to 13th March will be acceptable.

Please see the front of the exam paper for further information about setting the paper.

Awards

The award scheme is as follows:

Award	Mark range
Participation	0 - 13
Bronze	14 – 25
Silver	26 – 37
Gold	38 – 50

Preamble:

Please award marks as indicated below.

Equivalent valid reasoning should gain equal credit to the solutions presented here.

Error carried forward marks may be awarded where an incorrect answer is used as part of the data needed for a subsequent question, providing that the resulting answer is not plainly ridiculous.

If incorrect units are used more than once then **one** mark should be deducted from the total.

If an inappropriate number of significant figures are given more than once in final answers then **one** mark should be deducted from the total.

Section 1 – Multiple Choice Questions [1 mark each]

1	2	3	4	5	6	7	8	9	10
B	B	D	B	A	D	E	C	B	A

Section 2 – Short Answer Questions

Marks for these two questions should be awarded for a clear explanation of the underlying Physical principals using correct scientific terminology. Answers that are incomplete, contain errors in Physics or use terminology incorrectly cannot be awarded full credit.

Award 0 marks:	No valid attempt made to answer question
Award 1 mark:	Valid point presented but other-wise incorrect or incomplete answer
Award 2 marks:	Partially correct answer but major error or omission in reasoning
Award 3 marks:	Mostly correct answer, only minor errors or omissions in reasoning
Award 4 marks:	Completely correct answer, no errors, omissions of reasoning or incorrect use of terminology

Any valid explanation should be awarded credit

Example solutions might include:

11. Stopping Distance [4 marks]

- For thinking distance, distance travelled is v x t and t is reaction time
- Doubling speed will double thinking distance
- For the braking distance, deceleration will remain constant and so the area under the v-t graph will be 4x greater.
- OR Work done = ½ m v^2 shows that doubling the speed requires 4 x more work to be done to stop the car and so distance travelled is 4 x greater
- Doubling speed will more than double the braking distance
- Therefore total stopping distance will be more than doubled

12. Drinking straw [4 marks]

- Pressure on surface of liquid remains constant (atmospheric)
- Pressure in straw reduced
- There is a difference in pressure
- OR weight of liquid in straw is less than the force of the air pushing the liquid up the straw
- A net force is exerted on liquid in straw
- Forcing liquid to rise up the straw

Also allow: “weight of liquid in straw and force pushing liquid up the straw are equal as the liquid is not accelerating” (or in terms of pressure) as long as it is clear that the underlying Physics is understood and explained.

Section 3 – Longer Answers

13. Jam Jar

a) Use of $F = p \times A$ [1]

Correct use of $A = \pi r^2$ [1]

$F = 280$ N [1]

b) Use of p / T = constant for initial conditions [1]

Conversion of temperature to Kelvin [1]

Giving $p = 80$ kPa [1]

(use of Celsius giving $p = 18$ kPa scores 2)

c) Use of $F = \Delta p \times A$ [1]

$F = 56$ N [1]

d) T increases $\Rightarrow \Delta p$ decreases [1]

Δp decreases $\Rightarrow$ F decreases (OWTTE) [1]

(Also allow expansion of metal lid as a valid answer)

14. Lightning strike

a) Correct calculation of cross sectional area [1]

Attempt to use $R = \rho L / A$ [1]

Giving $R = 2.3$ mΩ [1]

b) Use of equation to give $P = 200$ MW [1]

Use of $E = P \times t$ [1]

Giving $E = 410$ kJ [1]

c) Use of density equation and correct calculation of volume [1]

Giving $V = 0.012$ m^3 [1]

and mass = 107 kg [1]

d) Use of $\Delta E = m\, c\, \Delta T$ in some form [1]

Giving $\Delta T = 10$ °C [1]

And so won't melt [1]

15. Acceleration

This question is about developing a model for a complex motion. Reasonable answers should carry full credit and the answers given below are for guidance only.

Markers are encouraged to be generous.

a)	t = 0.0 to 1.0	a = 5.0	allow ± 0.2	m/s^2	[½]
	t = 1.0 to 2.0	a = 3.5	allow ± 0.2	m/s^2	[½]
	t = 2.0 to 3.0	a = 2.6	allow ± 0.2	m/s^2	[½]
	t = 3.0 to 4.0	a = 2.25	allow ± 0.2	m/s^2	[½]

b) Horizontal straight lines [1]

(Alternatively points at 0.5 s, 1.5 s etc would be acceptable)

Correct / corresponding to (a) above [1]

c) Diagonal straight lines getting less steep with correct gradient / corresponding to (b) above [1]

Correct values (at least one) given on y-axis [1]

d) Attempt to use area under graph or suvat [1]

Correct area for their graph giving
distance travelled = 31 m allow ± 3 m [1]

e) This is clearly the most difficult question on the paper and credit should be given for an attempt at a reasonable answer that demonstrates some understanding of the model being used. As the model is very basic there are several different sets of values that could be used with equal validity

Use of difference in acceleration from 6 m/s^2 as an indication of drag force and appropriate numerical data taken from graphs correctly [1]

Use of ratios etc to justify Drag not being proportional to velocity [1]

Question 15 – possible solution

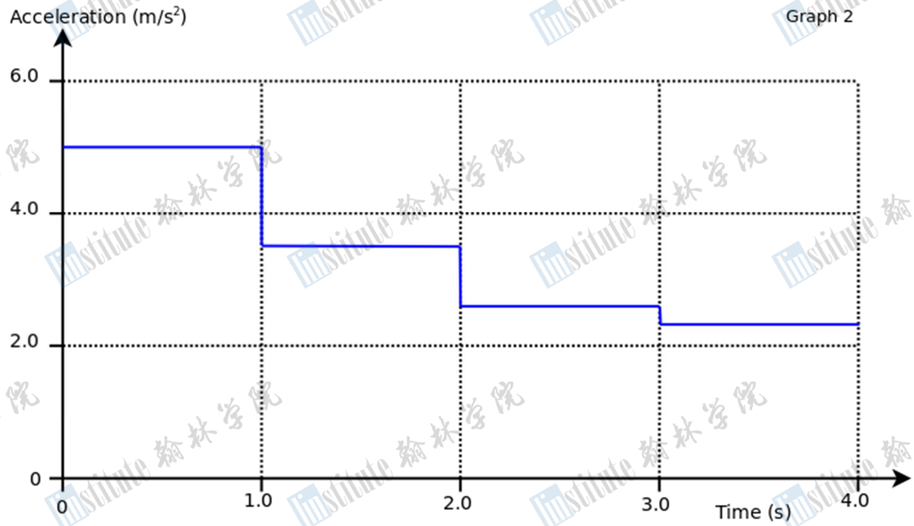
a) $t = 0.0$ to 1.0 $a = 5.0$ allow ± 0.2 m/s^2

$t = 1.0$ to 2.0 $a = 3.5$ allow ± 0.2 m/s^2

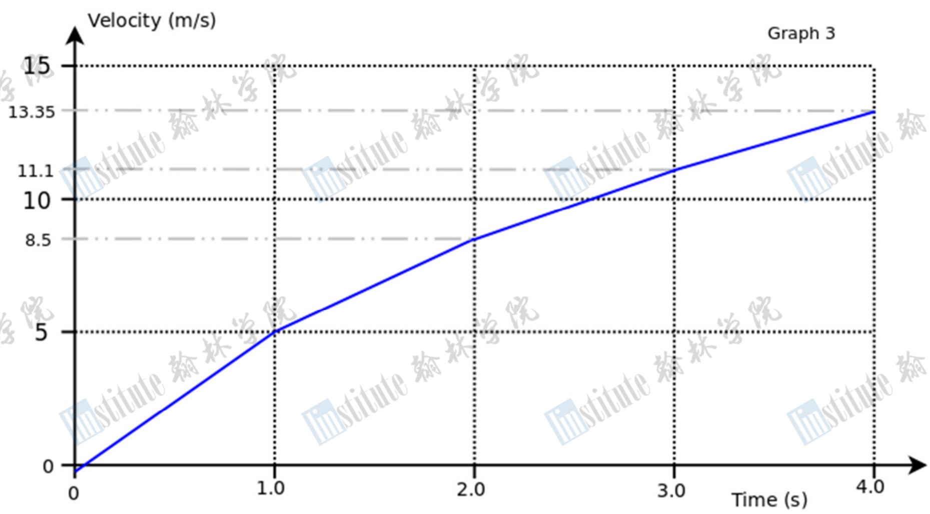
$t = 2.0$ to 3.0 $a = 2.6$ allow ± 0.2 m/s^2

$t = 3.0$ to 4.0 $a = 2.25$ allow ± 0.2 m/s^2

b)



c)



d) $S = (½ \times 1 \times 5) + (½ \times 1 \times 3.5) + (1 \times 5) + (½ \times 1 \times 2.6) + (1 \times 8.5)$

$+ (½ \times 1 \times 2.25) + (1 \times 11.1) = 31.275$ m

$= 31$ m

e) Let mass of car be M

Consider initial acceleration when there is no drag → driving force = 6 M

t = 1.0 s, graph 1 gives $a = 4$ m/s^2 → Drag = 2M, v = 5m/s, ratio = 2/5 = 0.4

t = 2.0 s, $a = 3$ m/s^2 → Drag = 3M, v = 8.5m/s, ratio = 3/8.5 = 0.35

ratio changes → not proportional