

## Mark Scheme Physics Challenge 2004

### Mark Scheme Preamble

Please award marks as indicated below. Equivalent valid reasoning should gain equal credit to the solution presented below. Incorrect units should not be penalized the first time, but then one mark should be deducted for a second offence. No further marks should be deducted for incorrect units unless the mark scheme explicitly states otherwise. Use a similar procedure for inappropriate number of significant figures. For example the use of more than three significant figures in a final answer.

### 'Star' marks

Certain points on the mark scheme are deemed worthy of extra credit, and these are marked with the asterisk symbol (\*). **These count as normal marks when calculating the total.** However, please keep a separate record of how many star marks each student acquires.

Each script forwarded to the Olympiad office for the consideration of an award should have two totals indicated on the front in the boxes provided -- the total number of marks (star marks plus non star marks), out of a total of 52, and a separate indication of how many of the 15 star marks were awarded to that student. For example, you might write in the boxes provided [45,7\*]. In addition the marks should be entered on the entry form containing all the names of the candidates whose scripts are to be submitted.

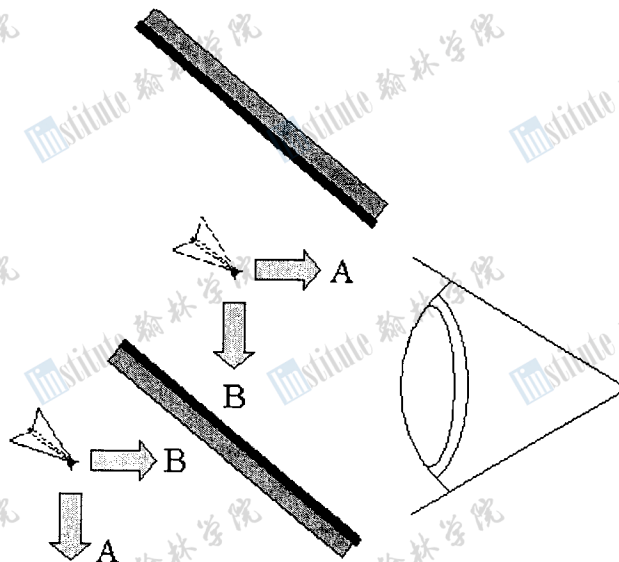
### Section A: Multiple Choice

One mark for each, question, 2, 5, 6, and 7 are **starred marks** (\*)

- |       |                     |
|-------|---------------------|
| 1. A  | <b>One Mark</b>     |
| 2. E  | <b>One Mark (*)</b> |
| 3. C  | <b>One Mark</b>     |
| 4. A  | <b>One Mark</b>     |
| 5. C  | <b>One Mark (*)</b> |
| 6. E  | <b>One Mark (*)</b> |
| 7. C  | <b>One Mark (*)</b> |
| 8. A  | <b>One Mark</b>     |
| 9. D  | <b>One Mark</b>     |
| 10. D | <b>One Mark</b>     |

**Section B: Written Answers**

11.



- a) **One mark** for the position of the image clearly at the same distance from surface of mirror.  
**One mark** ( \* ) for the correct orientation of the fly.
- b) **One mark** for correctly showing the arrow labelled A.
- c) **One mark** for correctly showing the arrow labelled B.
- 12 a) **One mark** for pointing out that the resistor gets hot when a large current passes, and ignites the fuel.
- b) **One mark** for  $E = IVt$   
**One mark** for  $4 \text{ V} \times 5 \text{ A} \times 0.5 \text{ s} = 10 \text{ J}$
- c) **One mark** for  $24 \text{ V} \times I \times 0.05 \text{ s} = 10 \text{ J}$   
**One mark** ( \* ) for  $I = 10 \text{ J} / (24 \text{ V} \times 0.05 \text{ s}) = 8.3 \text{ A}$
- d) **One mark** for  $24 \text{ V} / 8.3 \text{ A} = 2.9 \Omega$
- e) **One mark** for indicating that the resistance increases,  
**One mark** for mentioning that this occurs as the temperature increases.
- 13 a) **Two marks** for  $E = 5000 \text{ J}$  (knowing that  $1 \text{ V} = 1 \text{ J/C}$  and applying it).
- b) **One mark** for  $E = F(5 \times 10^{-3}) \text{ J}$  for  $1 \text{ C}$ .  
**One mark** ( \* ) for  $F = 5000 \text{ J} / (5 \times 10^{-3}) = 1 \times 10^6 \text{ N}$  or  $\text{N/C}$  acceptable.
- c) **One mark** for the **magnitude** of the electric field strength  
 $\epsilon = V/d = 15 \times 10^3 \text{ V} / 5 \times 10^{-3} \text{ m} = 3 \times 10^6 \text{ V/m}$  (or  $\text{N/C}$ )  
**One mark** ( \* ) for the unit  $\text{V/m}$ , or  $\text{N/C}$ .
- d) **One mark** for recognising that the above is the potential difference per metre required for a spark.  
**One mark** for  $1500 \text{ m} \times 3 \times 10^6 \text{ V/m} = 4.5 \text{ GV}$ .

- 14 a) **One mark** for area of circle =  $\pi R^2 = \pi(5.0)^2 = 78.5 \text{ m}^2$ .  
**One mark** ( \* ) for volume =  $78.5(7.00) = 550 \text{ m}^3$ .  
 b) **One mark** for mass =  $550(1.30) = 715 \text{ kg}$ .  
 c) **One mark** for K.E =  $\frac{1}{2}(715)(7.0)^2 = 17.5 \text{ kJ}$ .  
 d) **One mark** for Power output =  $17.5(0.40) = 7.0 \text{ kW}$   
 e) **One mark** ( \* ) for Current,  $I = P / V$   
 $= 7000 / 1000 = 7.0 \text{ A}$   
**One mark** for Power =  $I^2 R = (7.0)^2 15 = 735 \text{ W}$ .  
**One mark** for Fraction of power lost =  $735 / 7000 = 0.105$

- 15 a) **One mark** for  $s = \frac{1}{2} at^2$   
**One mark** for  $s = \frac{1}{2} \times 10 \times (1.0)^2 = 5.0 \text{ m}$ .  
 or  
**One mark** for speed at 1.0 s = 10 m/s if it is accelerating at  $10 \text{ m/s}^2$ .  
**One mark** for  $s = \text{average speed} \times t = \frac{1}{2}(10 \text{ m/s}) \times 1.0 \text{ s} = 5.0 \text{ m}$ .  
 b) **One mark** for arguing that if acceleration is  $g/3600$  then distance fallen in 1s is  $(1/2)(10/3600)$   
**One mark** for  $(5/3600) \text{ m} = 1.39 \text{ mm} \approx 1.4 \text{ mm}$  to 2 s.f.  
 c) **One mark** ( \* ) for  $d = 2\pi \times 384\,000 \text{ km}$ ,  
 $t = 60 \times 60 \times 24 \times 28 \text{ s}$   
**One mark** ( \* ) for,  
 $2\pi \times 384\,000 \text{ km} / (60 \times 60 \times 24 \times 28) \text{ s} = 0.997 \text{ km/s} \approx 1.0 \text{ km/s}$ .

- d) **One mark** for 1.0 km.  
 e) **One mark** for  $OA^2 + AB^2 = OB^2$   
**One mark** ( \* ) for  $r^2 + (1.0)^2 = (r + x)^2$   
**One mark** ( \* ) for  $r^2 + (1.0)^2 = r^2 + 2rx + x^2$   
**One mark** for  $(1.0)^2 = 2rx + x^2$   
 f) **One mark** ( \* ) for recognising that  $x^2$  is negligible so  
 $x = (1.0)^2 / 2r \text{ km}$

(clearly you should give the mark, without the star even if they have not noticed that  $x^2$  is negligible and have just used the calculator mechanically)  
**One mark** for  $x = [(1.0)^2 / (2 \times 384000)] \text{ km} = 1.3 \text{ mm}$  (essentially a mark for putting in the numbers).

# PHYSICS CHALLENGE COMMENDATION CERTIFICATE

Students whose scripts have not been submitted but have obtained 20, or more, marks will receive a Commendation Certificate. Teachers should apply on the form below.

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## PHYSICS CHALLENGE CERTIFICATES

**NO. OF CERTIFICATES REQUESTED:**

**NAME OF TEACHER:**

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**NAME OF SCHOOL:**

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**ADDRESS OF SCHOOL:**

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**Please return this slip to:**

**Dr. Cyril Isenberg  
Physics Challenge  
BPhO Office  
Department of Physics & Astronomy  
University of Leicester  
University Road  
Leicester LE1 7RH**