Mark Scheme Physics Challenge 2006

Please award marks as indicated below. Equivalent valid reasoning should gain equal credit to the solution presented here. Schools may give 'error carried forward' marks where an incorrect answer is used as part of the data needed for a subsequent question, providing that the resulting final answer is not plainly ridiculous. OWTTE means, 'or words to that effect'.

If **incorrect units** are used more than once in the paper, one mark should be deducted from the pupil's total. If an inappropriate number of **significant figures** are given more than once in final answers on the paper, then one mark should be deducted from the pupil's total.

Certain points are worthy of special credit, and have been given '**star marks**' (*). These are counted together with the normal marks in each student's total. The staff at the Olympiad office would be grateful if the two boxes on the front of the paper were filled in. The first box should contain the student's total mark (star marks included). The second box should contain the number of star marks the pupil earned.

Section A: Multiple Choice

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

Section B: Written Answer

11.		$v = 36$ km/h = 10 m/s	[1]
		Truck drops a height $h = v^2/2g = 5$ m	[1*]
		Tangent ~ 1/10, actually 0.101 to 3 s.f.	[1*]
		Question Total	*3 including 2**
12.	a)	16 × rate of rotation = 320 Hz ∴ rate = 20 rev/s	[1*]
		So, 24 × (4/3) × 20 rev/s = 640 Hz.	[1]
	b)	Twice the frequency/higher pitch by a factor of 2/up an octave	[1]
	c)	Pulsed air jet OWTTE	[1]
		producing a square wave of frequency equal to the rate at which the air jet is pulsed OWTTE	[1]
		Question Total	*5 including 1**
13.	a)	$10{,}000 \times 10{,}000\ \text{V} \times 1.6 \times 10^{-19}\ \text{C} = 1.6 \times 10^{-11}\ \text{J}$	[1]
	b)	1.6×10^{-11} J	[1*]
	c)	$10{,}000 \times 10{,}000\ \text{V} \times 8 \times 1.6 \times 10^{-19}\ \text{C} = 1.3 \times 10^{-10}\ \text{J}$	[1]
		Question Total	*3 including 1**

14 a) $t = ((2 \times 20\ m)/10\ m/s^2)^{1/2} = 2\ s$ [2]

b) 50 km/h = 13.9 m/s $\Rightarrow$ d = 27.8 m [1]

c) The car was exceeding the speed limit. It reached a horizontal distance of 50 m after leaving the road. [2]

Question Total *5 including 0**

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15 a) Light power = 1 kW/m^2 $\times$ 10 m^2 = 10 kW [1]

Electrical power = 10 kW $\times$ 0.3 = 3 kW [1]

Current = 3000 W/230 V = 13.0 A [1]

b) Area $\perp$ to the Sun's rays = 10 m^2 $\times$ cos(20°) [1*]

Power = 1 kW/m^2 $\times$ 10 m^2 $\times$ cos(20°) = 9.40 kW [1]

Energy = 9.40 kW $\times$ 120s = 1.13 MJ [1]

c) More energy per minute [1]

Rays from the sun spread out as light moves out into the solar system [1]

$\therefore$ more rays hit each m^2 of Venus' surface than hit the same area on Earth [1*]

d) If 1 kW of sunlight lights 1 m^2 on Earth and you trace your rays back, they form a 2/3 m by 2/3 m on Venus. So 1 kW of sunlight falls on each 2/3 $\times$ 2/3 m^2; that is, 2.25 kW/m^2 on Venus [1*]

Output power on Venus 2.25 kW $\times$ 10 m^2 $\times$ 0.3 = 6.75 kW [1*]

Question total *11 including 4**

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16 a) Graph axes labelled with units [1]

Points correctly plotted [1]

Line drawn with ruler [1]

Gradient taken: -0.87 (range allowed -0.85 to -0.89) [1]

Rate of reduction of mass = 0.87 g/s (must have unit) [1]

b) I $\times$ V = 240V $\times$ 8.3A = 1992 W [1*]

Energy to change state of 1 kg of water to steam

= 1992 W/(0.87 $\times$ 10^{-3} kg/s) = 2.3 MJ [1*]

c) 0.1 kg steam condenses into water at 100 °C [1*]

0.23 MJ delivered to the 0.9 kg of water at 0 °C [1*]

1 kg water requires 4200 J to rise 1 °C

$\therefore$ 0.9 kg water requires 3780 J to rise 1 °C [1*]

$\therefore$ the 0.9 kg of water at 0 °C will rise 60.8 °C by heat from condensation [1*]

We now have a mixture of 0.9 kg of water at 60.8 °C and 0.1 kg of water at 100 °C.

0.9 kg of water needs 3780 J to rise by 1°C

0.1 kg of water needs 420 J to fall by 1 °C

$\therefore 9 \times$ rise in temp of 0.9 kg $= 1 \times$ fall in temp of 0.1 kg

$9 \times (x - 60.8) = (100 - x)$ [1*]

$x = 64.8$ °C. [1*]

Question total	*13 including 8**

Total marks on paper **50 including 20***

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.

PHYSICS CHALLENGE
CERTIFICATES

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