British Physics Olympiad Paper 1: Solutions

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Mark Scheme **Sept/Oct 2009**

Allow ecf where this gives sensible answers

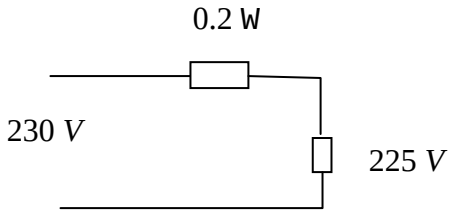
Q1.

(a) The mass is simply the sum of the two individual masses ✓
i.e.97 kg ✓

(2 marks)

(b)

i) Diagram of the form:



✓

ii) 5 V drop across 0.2 W resistor ✓
leads to a current of 25 A maximum ✓
So power available at 225 V is 5.63 kW ✓

(4 marks)

(c)

i) Sound energy = 0.1 x *mgh* $= 0.1 \times 2 \times 10^{-4} \times 9.8 \times 1$
$= 2 \times 10^{-4}$ J ✓

ii) Assume (maybe implicit) - Energy is spread over half of a sphere
Or allow for whole sphere and energy absorbed by ground
But some comment should be made about the assumption ✓

Ear receives energy = $2\times10^{-4} \times \dfrac{\pi(6\times10^{-3})^2}{4} \Big/ \dfrac{1}{2}4\pi5^2$ ✓

$= 3.6\times10^{-11}$ J ✓

(4 marks)

(d) An image is formed on the screen (✓) and your eye now focuses rays of light which come from each point on the screen to form a new image. A mirror would direct rays from the room to your eye from other parts of the room. (✓)

(2 marks)

(e) There are several approaches:
For (a), since $E = V/d$ then E halves (as d doubles), ✓
so Q halves, V is constant and hence energy stored halves. ✓

For (b), Q is constant, so E is constant, so V doubles ✓
For constant Q then the energy doubles ✓
Ratio is 1:4 allow marks if answer given (not guessed)

(4 marks)

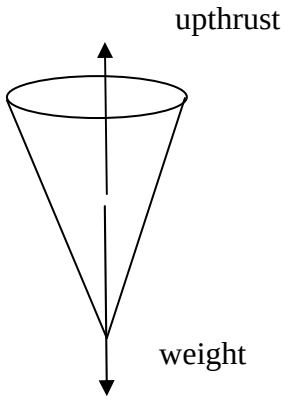
(f) Amplitude → amplitude/4, so energy → energy/16 ✓
This is four half lives ✓
so time taken is 8.0 seconds, i.e. 1800 oscillations (ecf) ✓

(3 marks)

(g)

i) Archimedes upthrust/weight of the liquid displaced/etc. ✓

ii) Sketch:



✓

iii) By similar triangles:

$$\frac{R}{r} = \frac{h}{\ell}$$ ✓

iv) From the forces: weight of cone = weight of liquid displaced

$$\rho_c \frac{1}{3}\pi R^2 hg = \rho_w \frac{1}{3}\pi r^2 \ell g$$

substituting for $\frac{h}{\ell}$ ✓✓✓

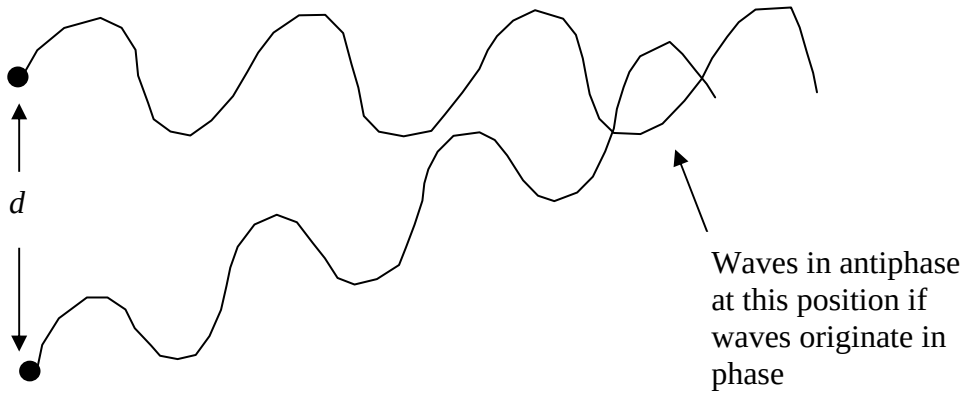
$$\rho_c h^3 = \rho_w \ell^3$$

$$\frac{\rho_c}{\rho_w} = \left(\frac{\ell}{h}\right)^3$$

(6 marks)

(h) i) Frequency remains the same ✓
the speed increases (as the ray bends away from the normal) ✓
wavelength increases ✓

iii) Diagram of the form shown below,
or with semicircles emerging
or any alternative clear and reasonable interpretation ✓



iii) minimum d is $d_{min} \approx \lambda/2$ ✓
orientation: the two waves are collinear with the centres of the speakers ✓
(6 marks)

(i) Angles shown to indicate angle q_e with angle of 102^o inside the glass - 3 marks

Or statement that emerging ray is "above" the normal justified ✓

Two marks for suitable correct rays and angles ✓✓

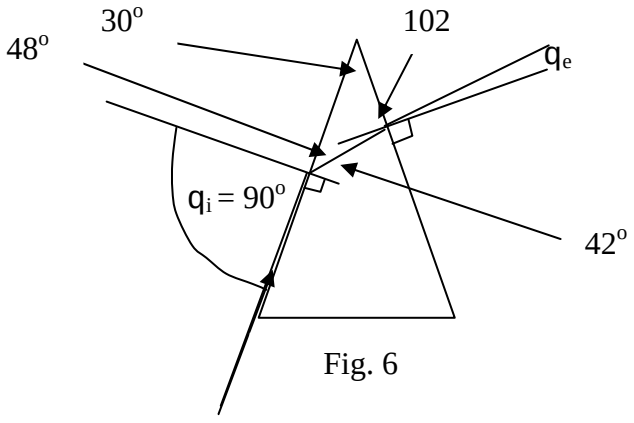


Fig. 6

(3 marks)

(j) Field increases as $1/r^2$. So calculation is

$$\frac{B_1}{B_2} = \frac{R_2^2}{R_1^2}$$

$$\frac{10^{-2}}{B_2} = \frac{(10)^2}{(1.4\times10^6)^2}$$

$$B_2 = 10^{-2}\times10^{-2}\times1.96\times10^{12}$$

$$B_2 = 2.0\times10^8\,\text{T}$$

Right idea ✓, numbers substituted ✓✓, answer ✓

(4 marks)

[Q1: 38]

Q2.

i) $m = const\times v^a \times g^b \times \rho^c$ ✓

(1 mark)

ii) The dimensions are given by

$[v] = LT^{-1}$, $[g] = L\,T^{-2}$, $[r] = ML^{-3}$ ✓✓✓

So then we can write

$M = (LT^{-1})^a \times (LT^{-2})^b \times (ML^{-3})^c$ ✓

(4 marks)

iii) The powers of M, L, T on each side of the equation must be the same

.

For M: $M^1 = M^c$ so that c = 1 ✓

For L: $L^0 = L^{a+b-3c}$ so that a + b -3c = 0 ✓

For T: $T^o = T^{-a-2b}$ so that -a – 2b = 0 ✓

b = -3 and a = 6 ✓

(4 marks)

iv)

$m = const\times v^6 \times g^{-3} \times \rho$

or all correct: ✓✓

$$m = const\,\frac{v^6\rho}{g^3}$$

(2 marks)

v) The high power of *v* means that for a small increase in *v* there will be a relatively large increase in v^6. owtte ✓

(1 mark)

[Q2: 12]
