BRITISH PHYSICS OLYMPIAD 2014-15

A2 Challenge Solutions

1 a) i) Momentum ☑

ii) mgh ☑ $\sqrt{(2gh)}$ ☑

iii) mgh ☑ h ☑

b) i) $\sqrt{}$(2gh), downwards ☑

ii) $\sqrt{}$(2gh), upwards ☑ $2\sqrt{(2gh)}$ ☑

iii) $2\sqrt{(2gh)}$ ☑ $3\sqrt{(2gh)}$ ☑

iv) $9h$ ☑

c) Speed after falling 1m = $\sqrt{(2gh)}$ = $\sqrt{}$(2x10x1)= 4.47ms^{-1} ☑

By the reasoning above, successive balls will rise at $3\sqrt{(2gh)}$, $7\sqrt{(2gh)}$, $15\sqrt{(2gh)}$, $31\sqrt{(2gh)}$, $63\sqrt{(2gh)}$, $127\sqrt{(2gh,)}$ $255\sqrt{(2gh)}$, $511\sqrt{(2gh)}$, $1023\sqrt{(2gh)}$, $2047\sqrt{(2gh)}$, $4095\sqrt{(2gh)}$ *etc (spot that the coefficients 'double+ 1' each time)* ☑

As escape velocity is 2460 times 4.47ms^{-1}, 12 balls are required to reach escape velocity (Proposition not changed by use of g=9.81ms^{-2}) ☑

TOTAL 14

2 a) i) zero ☑

ii) a node ☑

iii) π or anything suggesting anti-phase (to give zero resultant displacement) ☑

0, 2π or anything suggesting in phase ☑

π, 3π , $(2n+1)\pi$ or anything else suggesting anti-phase ☑

b) i) virtual ☑

ii) both S, S' originate from same source and therefore must have a fixed phase difference **owtte** ☑

iii) Light does not go on that side of the reflector ☑

iv) $\lambda = xd/L$ ☑= 10^{-3} x 5x10^{-4} / 1.00 = 5x10^{-7}m ☑

v) Reflection introduces an extra phase difference of π, in addition to zero phase difference arising from geometrical p.d. ☑, so central fringe is dark/ zero intensity **owtte** ☑

vi) The zero-order in Young's fringes (with normal incidence) is an interference maximum. **owtte** ☑

TOTAL 13

3 a) i) $1/R = 1/R_1 + R_2$ **owtte** ☑

ii) correct re-arrangement to give $R = R_1R_2 / (R_1+R_2)$ ☑

b) i) 40Ω ☑

ii) ((40+20)||20) ☑(parallel part) + 20 = 35Ω ☑

iii) Now this becomes ((r+20)||20) + 20 ....realise this ☑

ie $\frac{20(r + 20)}{r + 40} + 20 = \frac{40r+1200}{r+40}$ **owtte** ☑

iv) Equating this to r ☑and solving☑ leads to $r = 20\sqrt{3}$ Ω

TOTAL 9

4 a) i) temperature higher than surroundings ☑

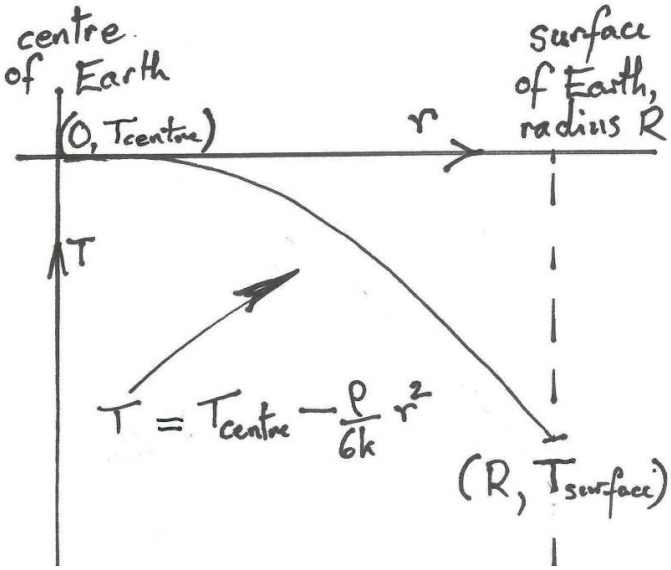
ii) As thermal energy travels down temperature gradient, ☑
Earth gets hotter towards centre. **owtte** ☑

iii) $4\pi r^3\rho/3$ ☑

iv) Area of shell is $4\pi r^2$, ☑
so total power output is $(4\pi r^2)x(-k\ \delta T/\delta r) = 4\pi r^3\rho/3$☑
Rearranging gives $\delta T = -(\rho/3k) r\,\delta r$ ☑

v) Integrating wrt *r* ☑and using $T=T_{centre}$ *when* r = *0* ☑
Leads to $T = T_{centre} - \rho r^2/6k$ ☑

vi)



Falls between centre and surface ☑
Parabolic form with vertex correctly placed ☑

b) They are much hotter in the centre than at the suface and may therefore reach ignition temperature. **owtte** ☑
Breaking such a hot and occluded body of combustible material open exposes it to air richer in oxygen which can cause it to erupt violently into flames. **owtte** ☑

TOTAL 14