2016

1) B

$T_1 = 1 \quad T_2 = ?$ and $\frac{86400}{T_1} - 300 = \frac{86400}{T_2}$

$T_2 = \frac{86400}{86100} = 1.00348\ s$

$2\pi\sqrt{\frac{L}{g}} = T_1$

, $L = 0.248\ m \implies T_2 = 2\pi\sqrt{\frac{L}{g_2}} = 1.00348 = 2\pi\sqrt{\frac{0.248}{g_2}}$

$g_2 = 9.762\ m/s^2$

2) A

Kepler's third law:

$\frac{T^2}{r^3} = \cancel{GM}\ \frac{4\pi^2}{GM} \qquad T = \sqrt{\frac{4\pi^2 r^3}{GM_E}}$

$T = 5735.78\ s = 95.59\ min$

3) D

$Power = \frac{mgdh}{dt} = mg\frac{dh}{dt} = mgv = 367.5\ W$

4) B

$mv = (M+M)V_f$

$(0.25)(25) = 2.25 \cdot V_f$

$V_f = 2.778\ m/s$

5) D

with an acceleration pointing backward by the brake, the liquid in the bottle would go forward with another acceleration. At this point, u can consider the liquid as another "mini box" which contains the bubble. When the liquid go forward with an acceleration, the bubble would move backward.

6) B

Recalling the equation:

$I(t) = \mathcal{E}\cdot\frac{1}{R}e^{-\frac{t}{RC}}$

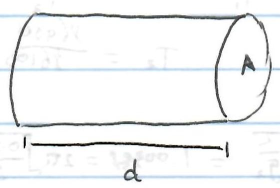
$\frac{\frac{\mathcal{E}}{R}}{2} = \mathcal{E}\frac{1}{R}e^{-\frac{t}{RC}}$

$\frac{1}{2} = e^{-\frac{t}{RC}}$

$\ln 2 = \frac{t}{RC}$

$t = RC\ln 2$

7) A



$$I = \frac{Q}{t} = e \cdot \frac{N}{t} = e \cdot \frac{\rho (A \cdot d)}{t}$$

ρ = density of electron

$$I = e \cdot \rho \cdot A \cdot V$$

and, for every copper molecule, there is only 1 free electron

$$\rho = \frac{9 \times 10^6}{\frac{63.5}{N_A}}$$

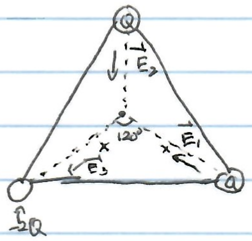
$$= \frac{9 \times 10^6 \cdot 6.022 \times 10^{23}}{63.5}$$

$$\rho = 8.5 \times 10^{28}$$

$$V = \frac{I}{e\rho \cdot A}$$

$$\approx 6 \times 10^{-5} \ m/s$$

8) D



$$L^2 = 2x^2 - 2x^2 \cos 120^\circ$$

$$L^2 = 2x^2 (1 - \cos 120^\circ)$$

$$L^2 = 3x^2$$

$$\sqrt{3} x = L$$

$$r = x = \frac{\sqrt{3}}{3} L$$

$$\vec{E_1} + \vec{E_2} = \sqrt{(E_1)^2 + (E_2)^2 + 2E_1E_2 \cos\theta}$$

$$= \sqrt{\cancel{2}\left(\frac{kQ}{r^2}\right)^2 - \cancel{2}\left(\frac{kQ}{r}\right)^2 \cos 120^\circ}$$

$$\vec{E_2} + \vec{E_1} = \left(\frac{kQ}{r^2}\right)$$

$$\vec{E_3} = -\frac{2kQ}{r^2}$$

$$|\vec{E_1} + \vec{E_2} + \vec{E_3}| = \frac{kQ}{r^2} + \left|-\frac{2kQ}{r^2}\right|$$

$$= \frac{3kQ}{r^2}$$

$\cancel{3kQ}$

$$= \frac{3kQ}{\left(\frac{\sqrt{3}}{3}L\right)^2}$$

$$= \frac{9kQ}{L^2}$$

9) A

$$\lambda = \frac{v}{f} \qquad v = c = 3 \times 10^8 \ m/s$$

$$= \frac{3 \times 10^8}{100 \times 10^6}$$

$$= 3 \ m$$

10) B

$$\frac{P}{4\pi r^2} = I = 800 \frac{W}{m^2}$$

$$\frac{P}{4\pi} = 800$$

$$P = 3200\pi \ W$$

$$\frac{P}{4\pi(10)^2} = I_2 = \frac{3200\pi}{4\pi \cdot 100} = 8 \frac{W}{m^2}$$

11) A

$t_p = 100ns$ = intrinsic lifetime

$$t = \frac{t_p}{\sqrt{1-(\frac{v^2}{c^2})}}$$

$$t = \frac{100}{\sqrt{1-0.36}}$$

$$t = 125ns$$

12) C

$E = hf$ = energy per photon   Intensity unchange = power unchange

Therefore, the number of photon must decrease because P remains constant.

13) A

According to the equation $\frac{\lambda L}{d} = \Delta y$ If d gets small Δy increases

14) A

According to Newton's third Law, Forces appear in pairs with an equal magnitude and opposite direction as another.

15) D

$$\frac{mv^2}{r} = mg + F_N$$ minimum occurs when $F_N = 0$

$$\frac{mv^2}{r} = mg + 0$$

$$V = \sqrt{gr}$$

$$mgh = \frac{1}{2}mv^2 + 2mgr$$

$$h = \frac{5}{2}r$$

16) C

$\frac{1}{2}mv^2$ = initial kinetic energy

45° up:

$\frac{1}{2}mv^2 = mgh$ h = from the roof to the h where $V_y = 0$

$\frac{1}{2}mv_{f_1}^2 = \frac{1}{2}mv^2 + mgx$ x = height of the building

45° down:

$\frac{1}{2}mv_{f_2}^2 = \frac{1}{2}mv^2 + mgx$ $V_{f_1} = V_{f_2}$

17) D

By observing the angles $n_1 < n_2$ and $n_3 < n_2$

while $\theta_3 > \theta_1$, $n_1 \sin\theta_1 = n_3 \sin\theta_3$

therefore, $n_3 < n_1 < n_2$

and $\frac{c}{V_3} < \frac{c}{V_1} < \frac{c}{V_2}$

$= V_3 > V_1 > V_2$

18) B

$P = I \cdot V$

when 2 heaters are in series, the 120V voltage is going to be shared between two heaters. Therefore, the heat produced must be decreased.

19) C

A is closer to the North pole, so the shift of the magnet would repel it to the left. B is closer to the south pole, and the shift of the magnet would attract it to the left.

20) B

$\frac{Q}{\Delta t} = \frac{kA\Delta T}{d}$

For B, the Area with the floor is greater than the Area between the string and the B. Therefore, A is losing Temperature faster than B.

21) D

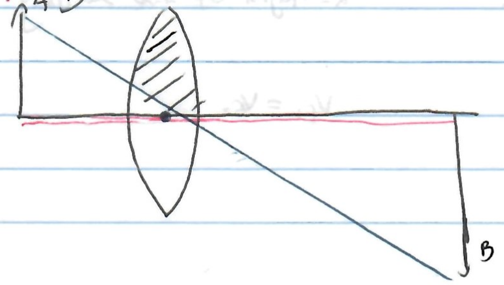
considering a square with side length L

when there is a change in T

$L_f = L(1 + \alpha\Delta T)$

and this observation also applies on the square hole.

22) D



By the Red line and the Blue Line, you can tell that the image B is still going to form and remain its position. therefore, only D is correct.

23) B

By $m = -\frac{d_i}{d_o}$ u can tell that as d_i gets further, there are going to be more distortion. Therefore, the answer is B

24) C

$$\frac{GM}{r^2} = g$$

$$9.75 = \frac{6.67 \times 10^{-11} \cdot 5.972 \times 10^{24}}{(6378 \times 10^3 + h)^2}$$

$$(h + 6.378 \times 10^3)^2 = 4.085 \times 10^{13}$$

$$h + 6.378 \times 10^3 = 6.3917 \times 10^6$$

$$h = 14000 m$$