## 2017 HCI Prelim H2 Physics Paper 1 Answers and Solutions

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | D | 6 | C | 11 | C | 16 | B | 21 | D | 26 | C |
| 2 | C | 7 | B | 12 | B | 17 | A | 22 | C | 27 | D |
| 3 | C | 8 | B | 13 | A | 18 | C | 23 | A | 28 | A |
| 4 | C | 9 | B | 14 | A | 19 | B | 24 | C | 29 | C |
| 5 | B | 10 | C | 15 | B | 20 | D | 25 | A | 30 | A |

**1 D**

$37.86\times10^{-4}\ \text{MJ cm}^{-4} = 37.86\times10^{-4}\ 10^{6}\text{J}\ (10^{-2}\ \text{m})^{-4}$

$= 37.86\times10^{-4}\times10^{8}\times10^{6}\ \text{J m}^{-4}$

$= 3.786\times10^{11}\ \text{m}^{-4}\text{J} = 378.6\times10^{9}\ \text{J m}^{-4}$

$= 378.6\ \text{GJ m}^{-4}$

**2 C**

Estimate the population as 6 million people and the land as 700 km².

$$\frac{6\times10^{6}}{7\times10^{2}\ \text{km}^{2}} \approx 10^{4}\ \text{km}^{-2}$$

**3 C**

The distance travelled by each vehicle is given by the area under their respective graphs.

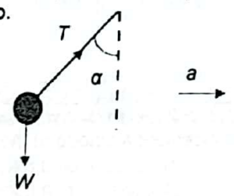
For both car and lorry, the distance travelled between 0 and 40 seconds is the same at 400 m.

This means the separation distance is zero at 40 s, which is also the least distance.

**4 C**

Option A: True. At the uniform speed the rope does not experience any horizontal acceleration. Hence, the angle is zero.

Option B: True.




$T \sin \alpha = ma$
$T \cos \alpha = W = mg$
$\tan \alpha = a / g$

Option C: False. Tension is $W / \sin \alpha$ when it is accelerates. Tension is equal to $W$ when it moves with a uniform speed. $W / \sin \alpha > W$

Option D: True. When the car decelerates, the net horizontal force is leftwards which swings the rope to the right.

**5 B**

Since the railway platform is in contact with the Earth, the Earth absorbs the vertical momentum, vertical component of the recoil is negligible.

Thus, considering the horizontal (x) components, by PCOLM,

$P_{1x} = - P_{2x}$ 1: bullet 2: gun
$M_1 v_1 \cos45° = - m_2 v_{2x}$
$v_{2x} = - (500)(200)\cos 45° / 70000 = - 1.01\ \text{ms}^{-1}$





**6 C**

Raw Power input = Rate of GPE converted to Electrical Energy

$= \frac{mgh}{t}$

$= \frac{\rho Vgh}{t}$

$= \frac{1000(6.0)(9.81)(80)}{1\ \text{sec}}$

= 4.7088 MW

Since Efficiency $= \frac{P_{out}}{P_{in}} = 0.60$

Then $P_{out} = 0.60 \times 4.7088 = 2.8$ MW

**7 B**

The driving force by the propeller equals the drag force on the boat when the boat is at constant speed.

$P_{engine} = F_{engine}v = F_{drag}v$
$30000 = F_{drag}(15.0)$
$F_{drag} = 2000$ N

Since $F_{drag} = kv^2$
$2000 = k\ (15.0)^2$
So drag constant k = 8.889

When v = 5.0 m s⁻¹,
$F_{drag} = kv^2 = 8.889 \times 5.0^2 = 222$ N
When the boat is being towed at constant speed at 5.0 m s⁻¹, the drag force equals the towline tension.

**8 B**

Maximum tension and speed occurs at the bottom of the vertical circular path. (resultant) Centripetal force is upwards.


$F_{net} = ma_c = mr\omega^2$
$37 - 5 = 0.5\ (4.00)\ \omega^2$
$\omega = 4.0\ \text{rad s}^{-1}$

**9 B**

For a mass, m, projected from a planet of mass M and radius r with escape velocity, $v_{esc}$ :
$\frac{1}{2} m v_{esc}^2 - GMm / r = 0$

$$v_{esc} = \sqrt{\frac{2GM}{r}}$$

$$(v_{esc})_{Earth} / (v_{esc})_{Mars} = \sqrt{\frac{M_{Earth}}{R_{Earth}}} / \sqrt{\frac{M_{Mars}}{R_{Mars}}} = \sqrt{\frac{M_{Earth}}{R_{Earth}}\frac{R_{Mars}}{M_{Mars}}}$$

**10 C**

Acceleration due to gravity at the surface of a planet of mass M and radius R,

$$g = \frac{GM}{R^2} = \frac{G(\rho\frac{4}{3}\pi R^3)}{R^2} = G\rho\frac{4}{3}\pi R$$

$$\frac{g_X}{g_Y} = \frac{\rho_X R_X}{\rho_Y R_Y} = \frac{2R_Y}{R_Y} = 2$$

**11 | C**

Heat lost by water = Heat gained by ice to just melt,
$M_{water}c_{water}(T - 0) = M_{ice}c_{ice}\Delta T + m_{ice}L_f$

$$T = \frac{2.0(2100)(20) + 2(3.35 \times 10^5)}{4.0(4200)} = 45°C$$

**12 | B**

From the formula list: $P = \frac{1}{3}\rho v_{rms}^2$

Therefore, $100\,000 = 0.178\, v_{rms}^2 / 3$

$v_{rms} = 1298 \text{ m s}^{-1} = 1300 \text{ m s}^{-1}$

**13 | A**

For an ideal gas, PV = Nrt

Hence, $\frac{V_2}{V_1} = \frac{T_2}{T_1}$

$\frac{100 \times 10^{-3}}{25 \times 10^{-3}} = \frac{T_2}{200}$

$T_2 = 800$ K.

Since $U = \frac{3}{2}nRT$

$\Delta U = \frac{3}{2}nR\Delta T = \frac{3}{2}(1)(8.31)(800 - 200) = 7479$ J

Other possible distractors: 5000 J (use PΔV with P = nRT/V = 66480 Pa)

**14 | A**

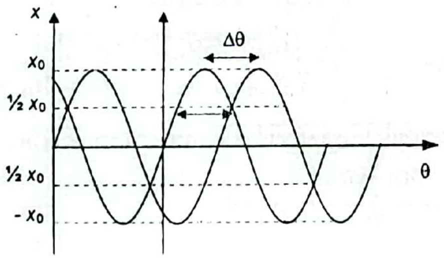
$\Delta U$ is negative.
At freezing point, temperature is constant, thus microscopic KE remains unchanged, but molecules are held more strongly together by intermolecular forces of attraction, the microscopic PE decreases.

$q$ is negative as heat flows out of the system.
$w$ is positive as the substance contracts, volume decreases thus $p\Delta V < 0$.

**15 | B**

Since we are determining phase difference, it is easier to work directly in x- θ equation instead of x-t equation.

Determine the phase angle such at x = $x_0/2$: $x_0/2 = x_0 \sin\theta \Rightarrow \theta = \sin^{-1}(½) = 30°, 150°$



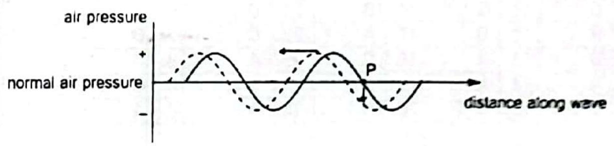

$\Delta\theta = 150° - 30° = 120°$





**16 | B**

The pressure variation "moves" along with the energy, compression and rarefaction will move to the left.




**17 | A**

Beyond A, the light intensity is always $I$.
B lets all of the light from A go through, implies that the axes of polarization of A and B are parallel.

With C between A and B:

angle between the axis of A and the axis of C = angle between the axis of C and the axis of B = θ

Beyond C, applying Malus' Law:

$$I_C = I\cos^2\theta$$

Beyond B, applying Malus' Law:

$$I_B = I_C\cos^2\theta$$

$$\frac{2I}{3} = (I\cos^2\theta)\cos^2\theta = I\cos^4\theta$$

$$\cos^4\theta = \frac{2}{3}$$

$$\theta = \cos^{-1}\left(\frac{2}{3}\right)^{\frac{1}{4}} = 25.4°$$

**18 | C**

The longitudinal stationary wave will form a displacement node at the closed (water) end and a displacement antinode at the open end (loudspeaker, with vibrating diaphragm)

**19 | B**

$V_1 = V_2$

$$\frac{kq_1}{r_1} = \frac{kq_2}{r_2}$$

$$\frac{q_1}{q_2} = \frac{r_1}{r_2}$$

$$\frac{E_1}{E_2} = \frac{kq_1/r_1^2}{kq_2/r_2^2} = \frac{q_1}{q_2} \times \frac{r_2^2}{r_1^2} = \frac{r_2}{r_1}$$

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| 20 | D | For the same p.d. V, resistance of wire decreases when its diameter decreases, since $R = \frac{\rho l}{A}$, and current increases as $I$ is proportional to $A$ as $I = \frac{V}{R} = \frac{AV}{\rho l}$.<br>Comparing with current $I = nv_d qA$<br>$\Rightarrow I$ is proportional to $A$ or $d^2$.<br>$v_d$ remains the same as it is independent of $d$. |
| 21 | D | Compute the effective resistance for each case. D having the smallest resistance draw the largest current. |
| 22 | C | By potential divider principle, increasing resistance of $R$ will decrease the p.d. across the potentiometer wire, and resulting in smaller p.d. per unit length. Thus balance point will be nearer to $M$. |
| 23 | A | The point charge's velocity is parallel to resultant magnetic flux density at the centre of the two wires. Thus magnetic force is zero. |
| 24 | C | To find maximum instantaneous speed:<br>$mg\Delta h = \frac{1}{2}mv^2 \rightarrow v = \sqrt{2gh} = \sqrt{2(9.81)(0.274)} = 2.32 \text{ m s}^{-1}$<br>maximum average speed = $\left(\frac{v}{2}\right) = 1.16 \text{ m s}^{-1}$<br>maximum induced e.m.f. = $Bl\left(\frac{v}{2}\right) = 1.5(0.800)(1.16) = 1.4 \text{ V}$ |
| 25 | A | Since inner loop experiences decreasing flux linkage, current in the inner wire will flow in the same direction as that in the outer wire to oppose this deceasing flux linkage (Lenz's law).<br>Since the rate of decrease of current with time is constant, the rate of decrease of B and hence flux linkage is constant, hence e.m.f. induced in inner loop is constant and the current in the inner loop is constant. |
| 26 | C | For sinusoidal a.c.<br>$V_{rms}(a) = V_{peak} / \sqrt{2}$<br>For the case of full square wave ac, $\langle P \rangle = V^2_{peak} / R$<br>Half-wave rectified square wave ac, $\langle P' \rangle = V^2_{peak} / 2R$<br>$V^2_{rms} / R = V^2_{peak} / 2R$<br>$V_{rms}(b) = V_{peak} / \sqrt{2}$<br>Thus the ratio is 1. |





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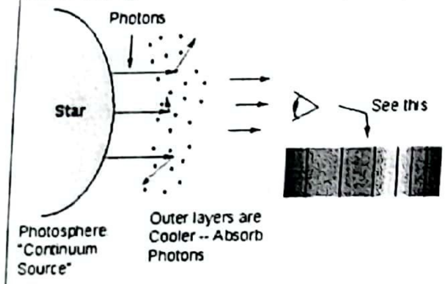
| 27 | D | In the solar absorption line spectra, the dark lines are caused by photons being absorbed by elements in the cooler photosphere, to excite to higher energy states.<br><br> |
| 28 | A | By conservation of energy, KE gained by electron = ePE lost by electron<br>$\frac{p^2}{2m} = eV \Rightarrow \frac{\left(\frac{h}{\lambda}\right)^2}{2m} = eV$<br>$\lambda = \frac{h}{\sqrt{2meV}}$<br>when $V$ is doubled,<br>$\lambda' = \frac{h}{\sqrt{2me2V}} = \frac{h}{\sqrt{2}\sqrt{2meV}}$<br>$\frac{\lambda' - \lambda}{\lambda} = \frac{\frac{h}{\sqrt{2}\sqrt{2meV}} - \frac{h}{\sqrt{2meV}}}{\frac{h}{\sqrt{2meV}}} = \frac{\frac{1}{\sqrt{2}} - 1}{1} = -0.29 = -29\%$ |
| 29 | C | Energy is released in nuclear fusion (not fission) reactions from nuclei in region P. |
| 30 | A | $^{8}_{3}Li \rightarrow ^{8}_{4}X + ^{0}_{-1}e$<br>$^{8}_{4}X$ has 4 protons and 4 neutrons, corresponding to A. |