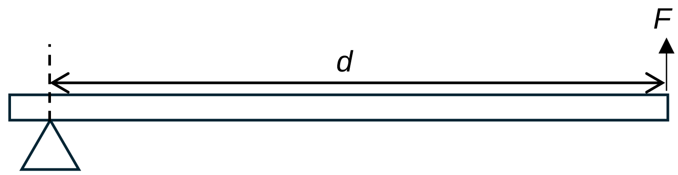
2024 Physics Prelim Exam H2 Paper 2 suggested solutions

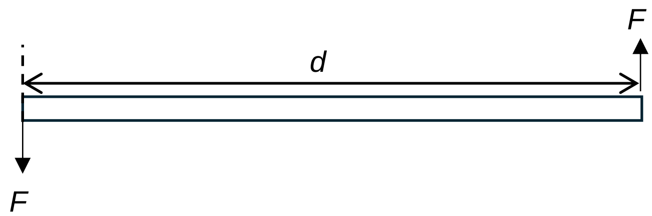
1(a) **Moment of a force:**



The moment of a force about an axis is the product of the force and the perpendicular distance [1] from the line of action of the force to the axis [1].

Minus 1 mark if no diagram given or diagram does not show corresponding *d* and *F* correctly.

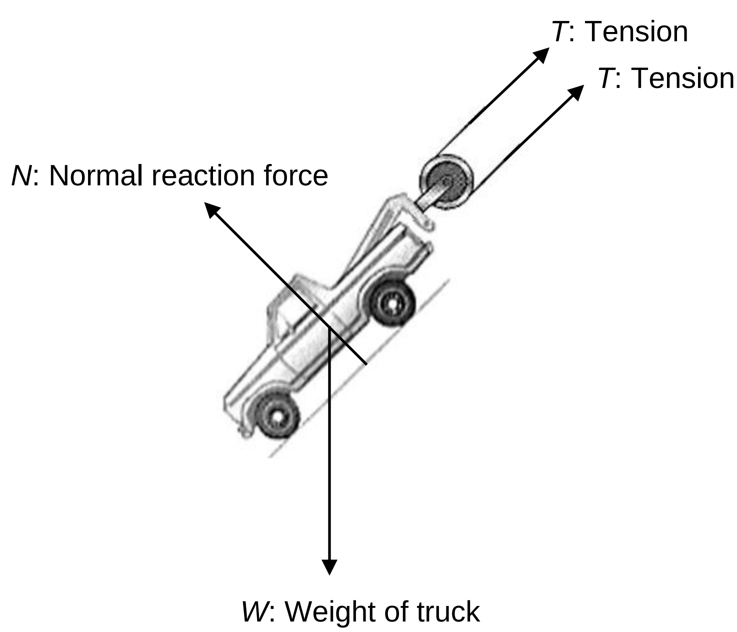
Torque of a couple:



Torque of couple is defined as the product of one force *F* [1] and the perpendicular distance $d_{\perp}$ between the two forces [1].

Minus 1 mark if no diagram given or diagram does not show corresponding *d* and *F* correctly.

(b)(i)



(b)(ii) Considering the truck in equilibrium:

$m_T g \sin 40° = 2T$ [1]

Taking moments about the centre of the pulley,

Sum of clockwise moments = sum of anti-clockwise moments

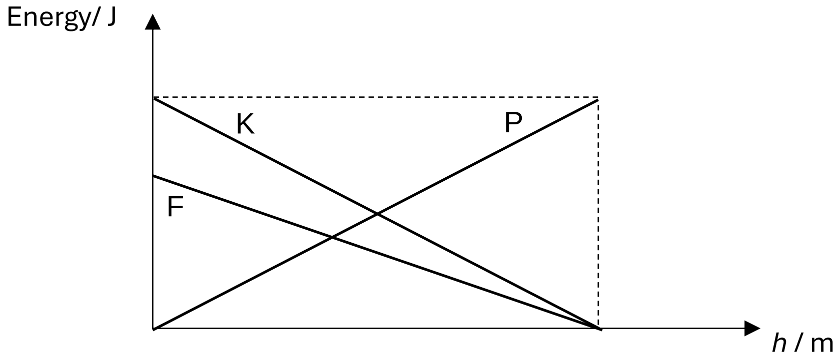
$mg \times 3r = T \times r$

$mg \times 3r = \frac{m_T g \sin 40°}{2} \times r$ [1m for correct clockwise expression, 1m for correct anti-clockwise expression]

$m = \frac{1500 \sin 40°}{2(3)}$

m = 161 kg [1]

2(a) (i)



1m for correct graph P

1m for correct graph K

(ii) 1m for correct graph F

Explanation:

Some potential energy lost will be converted to do work against friction [1], hence the gain in kinetic energy will be less as compared to the situation without friction. [1]

3(a)	momentum after elastic collision	$= -mu$	[1]
	time between collisions	$= 2L/u$	[1]
	number of collisions per unit time	$= u/2L$	[1]
	rate of change of momentum	$= -mu^2/L$	[1]
	average force	$= mu^2/L$	[1]

(b)(i) Gas molecules collide with one another elastically. [1]

(ii) Since collisions are elastic, the average speed of gas molecules incident on the wall remains the same. [1]

So frequency of collision between each wall and the molecule also remains unchanged. [1]

Therefore the pressure exerted on the wall is not affected.

(c) Given in (b) $pV = 1/3\ Nm\langle c^2\rangle$ - - - - (1)

By Ideal Gas Law: $pV = NkT$ - - - - (2) [1]

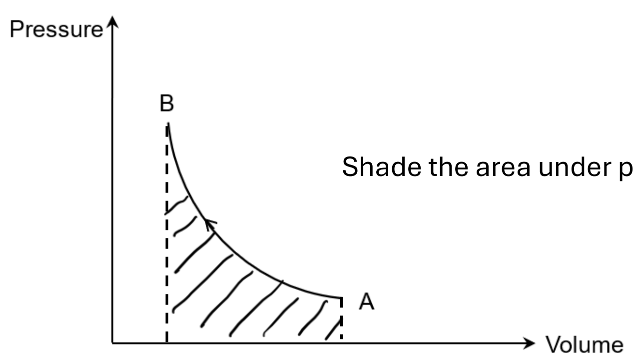
Equating (1) = (2) $1/3\ Nm\langle c^2\rangle = NkT$

=> $\frac{1}{2} m\langle c^2\rangle = 3/2\ kT$ [1]

Hence average ke, $\frac{1}{2} m\langle c^2\rangle = 3/2\ kT$

□ $\therefore$ Ave KE $\propto$ T (because k is a constant)

(d)(i)1.



Shade the area under p-V graph [1]

Fig 3.2

2. Since the process A -> B is such that ΔU = 0 (isothermal), and U = $\frac{3pV}{2}$ then

$p_A V_A = p_B V_B$. [1]

Hence there is no difference in the product $p_A V_A$ and $p_B V_B$. [1]

(ii) If the change takes place very quickly, there is no time for heat transfer with the surrounding. So it is an adiabatic change. i.e. $Q = 0$. [1]

Fig. 3.2 shows a compression. i.e. W is positive. So $\Delta U = Q + W$ is also positive. i.e. U increases. [1]

Since $U \propto c_{rms}^2$ of the molecules, it means the mean square speed of the molecules increases. [1]

,

4(a) Since the tube is in equilibrium,

Weight of (tube and ball bearings = Upthrust [1]

$$(m + M)g = AH\rho g$$

$$H = \frac{(M+m)}{\rho A}$$ [1]

(b) When the tube is displaced downwards by y, the upthrust will increase to $A(H+y)\rho g$ while the weight would remain the same as $(m+M)g$.

Hence the net force = $(m+M)g - A(H+y)\rho g$

$= (m+M)g - AH\rho g - Ay\rho g$

$= -A\rho g y$ since $(m + M)g = AH\rho g$

(negative means that the net force is opposite in direction to the displacement y) [1]

By N2L $(m+M)a = -A\rho g y$ [1]

$$a = -\frac{A\rho g}{m+M}y$$

(c) From (b) since $a = -\left(\frac{\rho A g}{M+m}\right)y$, thus a ∝ -y. Hence motion is S.H.M. [1]

Comparing with defining equation: a = - ω2 y, then:

[1]

$$\omega^2 = \frac{\rho A g}{M+m}$$

$$\omega = \sqrt{\frac{\rho A g}{M+m}}$$

$$\frac{2\pi}{T} = \sqrt{\frac{\rho A g}{M+m}}$$

$$T = 2\pi\sqrt{\frac{M+m}{\rho A g}}$$

$$= 2\pi\sqrt{\frac{0.012+0.025}{1.00\times10^3\times6.0\times10^{-4}\times9.81}}$$

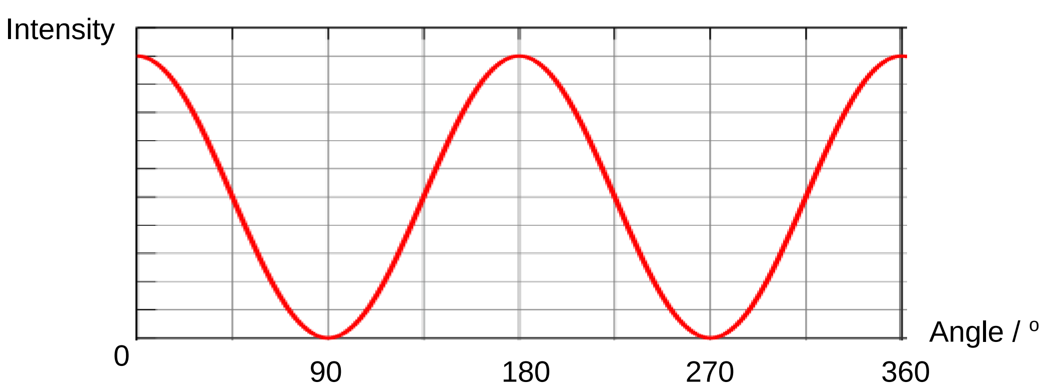
$$= 0.4982$$ [1]

$$= 0.50 \text{ s} \quad \text{(Shown)}$$

(d) As the test-tube oscillates, it experiences drag force exerted by the water .

This results in light damping and energy is gradually lost as heat. [1]

(e)(i)



Sinusoidal graph [1]

Label period 3.3 s [1]

(ii) The amplitude of oscillation is small because the frequency of the driving force (the waves) is too low (0.30 Hz) compared to the natural frequency of the test-tube (2 Hz). [1]

The amplitude of the oscillations can be increased by adding ball bearings to the test-tube to decrease the natural frequency so that it is closer to the frequency of the driving force. [1]

5(a) The direction of the induced emf is such as to produce an effect that opposes the change causing it [1]

(b)(i) X = 0.85 A [1]
Y = 2/ 0.040 [1]
= 160 rad s^{-1} [1]

(b)(ii) two cycles of a sinusoidal curve with a period of 0.040 s [1]
correct phase (i.e. V2 max / min at t = 0, 0.02, 0.04, 0.06 and 0.08 s, and V2 zero at t = 0.01, 0.03, 0.05, 0.07 s) [1]

maximum / minimum V_2 shown (consistently) at ± 6.5 V [1]

(b)(iii) (magnitude of) V_2 is proportional to rate of change of (magnetic) flux [1]

- V_2 is proportional to gradient of $I1–t$ curve
- V_2 has maximum magnitude when $I1–t$ curve is steepest
- V_2 is zero when $I1–t$ curve is horizontal / a maximum or minimum
- V_2 changes sign when sign of gradient of $I1–t$ curve changes

Any 2, give [1]

6(a)(i) From Fig 6.1 it can be observed that at specific wavelengths there were dips in the intensity meaning that the energy at these wavelengths were being absorbed. [1]

So this is an absorption spectrum. [1]

(ii) Transition from n = 3 to 2 should corresponds to the least energetic transition

i.e. transition giving rise to 656 nm line.

$$\Delta E_{656nm} = \frac{\left(6.63\times10^{-34}\right)\left(3.0\times10^{8}\right)}{656\times10^{-9}}$$
$$= 3.03\times10^{-19}\,\text{J}$$

$$E_3 = E_2 + \Delta E_{656nm}$$
$$= -5.44\times10^{-19} + 3.03\times10^{-19}$$
$$= -2.41\times10^{-19}\ \text{J}$$
$$= -1.51\text{eV}$$

(b)(i) If light behave as waves, then light waves should continuously transfer energy to the electrons to overcome the work function. [1]

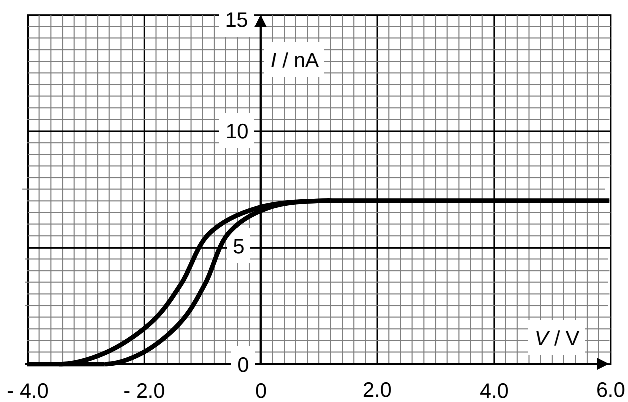
Even if lower frequency waves are used, the electrons can accumulate energy over time to gain enough energy to overcome the work function. [1]

Hence no minimum frequency should exist.

(ii) From graph, stopping potential V_s = 2.7 V [1]

$$\phi = \frac{hc}{\lambda} - eV_s$$
$$= \frac{(6.63\times10^{-34})(3.0\times10^{8})}{(184\times10^{-9})} - (1.60\times10^{-19})(2.7)$$ [1]
$$= 6.49\times10^{-19}\ \text{J}$$ [1]

(iii)



Graph with lower stopping potential [1]

7(a) Longitudinal wave – oscillations of wave particles parallel to direction of transfer of energy of wave [1]
Transverse wave – oscillation of wave particles perpendicular to direction of transfer of energy of waves [1]

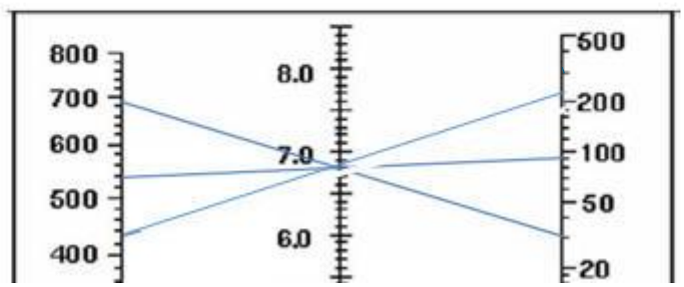
(b) S-waves cannot pass through the liquid outer core. [1]

(c)(i) Akita – 30 mm
Pusan – 56 s, 540-550 km,
Tokyo – 425-435 km, 210 mm

All amplitudes correct [1]
Time interval for Pusan correct [1]
Distance for Pusan (allow ecf) and Tokyo read correctly [1]

(ii) Understand must draw 3 circles center at stations [1]
All circles drawn with compass and correct scale [1]
Epicentre at KOBE [1]

(iii)1. -Distance from epicenter
-Scattering at boundary of different materials, cracks etc.
-Absorption due to rocks in Earth
Any other suitable answers [1]



Magnitude = 6.8 [2]

(d)(i) Ratio = $10^9/10^{6.8}$ = 158 [1]

1. The distance between the epicentre and the station. [1]

2. The above shows that a change in magnitude of 2.2 correspond to a change in intensity of about 160 times. Hence using a log scale allows us to compress the scale to more manageable numbers [1]

(ii) Ratio = $10^{(1.5)(2.2)}$ = 1995 (2000) [1]

(e) - Population density of the affected area might be low.

- The affected area might have stricter building codes that require buildings to have earthquake-proof features.