**VICTORIA JUNIOR COLLEGE**
**2021 JC2 PRELIMINARY EXAMINATION**
**Higher 2**

Name : ______________________  CT group : ______________

# PHYSICS

**9749/03**

Paper 3 Longer Structured Questions

**22 September 2021**

**WEDNESDAY**

Candidates answer on the Question Paper.

**8.00 am to 10:00 am (2 hours)**

No Additional Materials are required.

## READ THESE INSTRUCTIONS FIRST

Write your name and CT group in the spaces at the top of this page.

Write in dark blue or black pen on both sides of the paper. You may use an HB pencil for any diagrams, graphs or rough working. Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

**Section A**
Answer **all** questions.

**Section B**
Answer **one** question only.

You are advised to spend one and a half hours on Section A and half an hour on Section B.

The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| **1** | |
| **2** | |
| **3** | |
| **4** | |
| **5** | |
| **6** | |
| **7** | |
| **8** | |
| **Total** (max. 80) | |

This document consists of **24** printed pages.

**Data**

| | |
|---|---|
| speed of light in free space, | $c = 3.00 \times 10^{8}$ m s$^{-1}$ |
| permeability of free space, | $\mu_o = 4\pi \times 10^{-7}$ H m$^{-1}$ |
| permittivity of free space, | $\varepsilon_o = 8.85 \times 10^{-12}$ F m$^{-1}$<br>$(1/(36\pi)) \times 10^{-9}$ F m$^{-1}$ |
| elementary charge, | $e = 1.60 \times 10^{-19}$ C |
| the Planck constant, | $h = 6.63 \times 10^{-34}$ J s |
| unified atomic mass constant, | $u = 1.66 \times 10^{-27}$ kg |
| rest mass of electron, | $m_e = 9.11 \times 10^{-31}$ kg |
| rest mass of proton, | $m_p = 1.67 \times 10^{-27}$ kg |
| molar gas constant, | $R = 8.31$ J mol$^{-1}$ K$^{-1}$ |
| the Avogadro constant, | $N_A = 6.02 \times 10^{23}$ mol$^{-1}$ |
| the Boltzmann constant, | $k = 1.38 \times 10^{-23}$ J K$^{-1}$ |
| gravitational constant, | $G = 6.67 \times 10^{-11}$ N m$^{2}$ kg$^{-2}$ |
| acceleration of free fall, | $g = 9.81$ m s$^{-2}$ |

## Formulae

| | |
|---|---|
| uniformly accelerated motion, | $s = ut + (\frac{1}{2})at^2$<br>$v^2 = u^2 + 2as$ |
| work done on/by a gas, | $W = p\Delta V$ |
| hydrostatic pressure, | $p = \rho gh$ |
| gravitational potential, | $\phi = -\frac{GM}{r}$ |
| temperature | $T / K = T / °C + 273.15$ |
| pressure of an ideal gas | $p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$ |
| mean translational kinetic energy of an ideal gas molecule | $E = \frac{3}{2}kT$ |
| displacement of particle in s.h.m., | $x = x_o \sin \omega t$ |
| velocity of particle in s.h.m., | $v = v_o \cos \omega t$<br>$= \pm\omega\sqrt{(x_o^2 - x^2)}$ |
| electric current | $I = Anvq$ |
| resistors in series, | $R = R_1 + R_2 + \ldots$ |
| resistors in parallel, | $1/R = 1/R_1 + 1/R_2 + \ldots$ |
| electric potential, | $V = Q/4\pi\varepsilon_o r$ |
| alternating current/voltage, | $x = x_o \sin \omega t$ |
| Magnetic flux density due to a long straight wire | $B = \frac{\mu_0 I}{2\pi d}$ |
| Magnetic flux density due to a flat circular coil | $B = \frac{\mu_0 NI}{2r}$ |
| Magnetic flux density due to a long solenoid | $B = \mu_0 nI$ |
| radioactive decay, | $x = x_o \exp(-\lambda t)$ |
| decay constant, | $\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$ |

## Section A

Answer **all** the questions in this Section in the spaces provided.

1 A 2.0 kg box on a frictionless incline of angle 40° is connected by a cord that runs over a massless and frictionless pulley to a light spring of spring constant $k = 120$ N m$^{-1}$, as shown in **Fig. 1.1**. The box is released from rest along the inclined plane when the spring is unstretched.

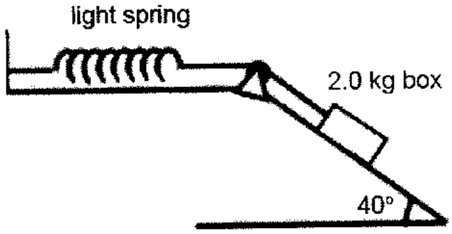


**Fig. 1.1**

**(a)** Calculate the energy stored in the spring when the box reaches 10 cm down the incline.

Energy stored = ........................ J [2]

**(b)** Determine, $D$, the distance along the incline moved through by the box before it comes to a stop.

$D$ = ........................ m [2]

**(c)** State what will happen to the answer calculated in **(b)** if the inclined angle is increased.

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(d) The frictionless incline is now replaced by a rough incline. Assuming the average friction between the rough incline and the box is 5.0 N, determine $D'$, the new distance moved through by the box before it comes to a stop.

$D'$ = ............................ m [2]

(e) Explain qualitatively how $D'$ might change if a spring with a bigger spring constant were used instead.

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2 In the design of space stations, one way to let the astronauts inside stand upright as if they are on Earth would be to spin a ring about an axis through its centre, as shown in **Fig. 2.1**.

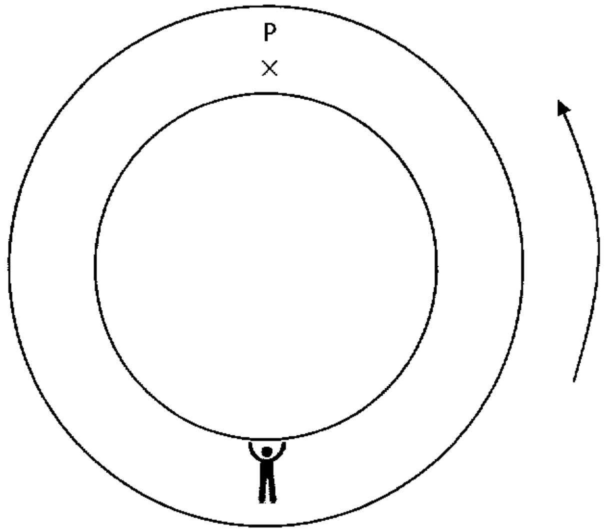


**Fig. 2.1**

An astronaut inside the station, who was initially floating weightlessly, grabs hold of the "ceiling" when the space station first starts to spin gradually from rest, as shown in **Fig. 2.1**. Assume that the space station is far away from any massive celestial bodies.

**(a)** Draw an arrow in **Fig. 2.1** to show the direction of the force that the astronaut experiences as the space station is *accelerating* to its final rotational speed. [1]

**(b)** Explain your answer to **(a)**.

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After the station has reached a constant angular speed, the astronaut, who is at point P in **Fig. 2.1**, releases his hold on the "ceiling".

**(c)** On **Fig. 2.1**, draw the trajectory that the astronaut will follow at the instant he releases his hold at point P. [1]

The astronaut is now able to stand upright like on Earth (see **Fig. 2.3**). However, he feels that his weight is different from that on Earth. He proceeds to perform an experiment in which he swings a bob attached to a light inextensible string so that it performs uniform circular motion in a plane that appears horizontal to him (see **Fig. 2.2**).

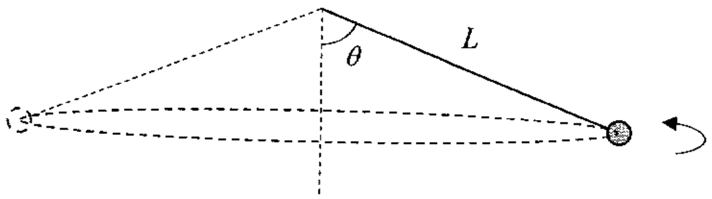


**Fig. 2.2**

The length $L$ of the string is 95.8 cm and the period of the circular motion is 1.185 s. The angle $\theta$ between the string and the vertical is 65.2°.

The rotational motion of the station causes the astronaut to undergo an acceleration $g$ towards the rotational axis of the station. This acceleration gives him the impression that he is experiencing weight.

**(d)** Determine the acceleration $g$ experienced by the astronaut due to the station's rotation.

$g$ = ................. m s$^{-2}$ [4]

By looking at the stars outside of the space station as it spins, the astronaut measures the period of rotation of the station to be 14.2 s.

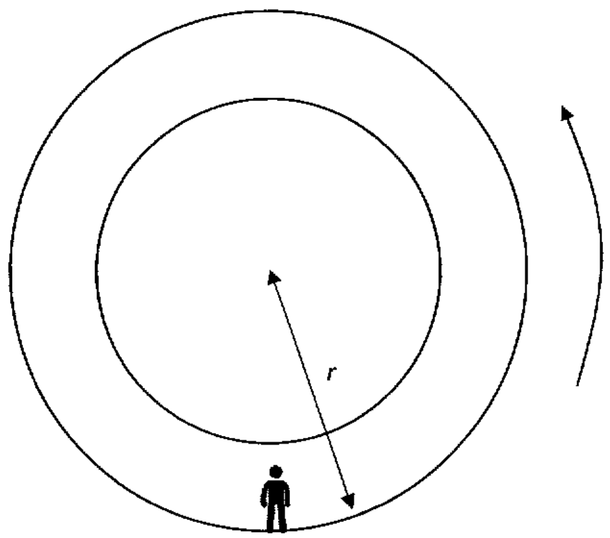


**Fig. 2.3**

**(e)** Determine the distance $r$ between the axis of rotation of the station and the "floor" on which the astronaut stands, as shown in **Fig. 2.3**.

$r$ = .................... m [2]

3 **(a)** State the First Law of Thermodynamics.

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**(b)** Starting from kinetic theory expression $p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$, show that the internal energy of a fixed mass of an ideal gas is equal to $\frac{3}{2}NkT$, where the symbols have their usual meaning.

[2]

**(c)** A fixed mass of an ideal gas undergoes a cycle of changes ABCDA, as shown in **Fig. 3.1**.

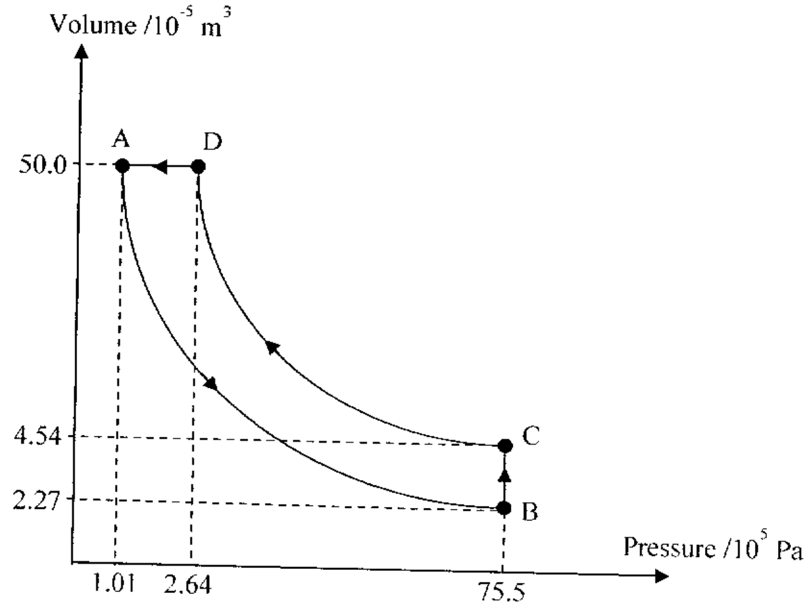


**Fig. 3.1 (not to scale)**

(i) For this mass of gas,

1. show that the increase in internal energy during the change from B to C is 257 J,

[1]

2. determine the work done on the gas during the change from B to C.

Work done = ......................[2]

(ii) Using your answers in **(c)(i)**, complete **Table 3.1** for the four stages of the cycle.

| Stage of cycle | heat supplied to gas / J | work done on gas / J | increase in internal energy of the system / J |
|---|---|---|---|
| A → B | 0 | 182 | |
| B → C | | | 257 |
| C → D | 0 | - 316 | |
| D → A | | | |

**Table 3.1**

[4]

4 **Fig. 4.1** shows two similar small loudspeakers driven in phase from a common audio-frequency source.

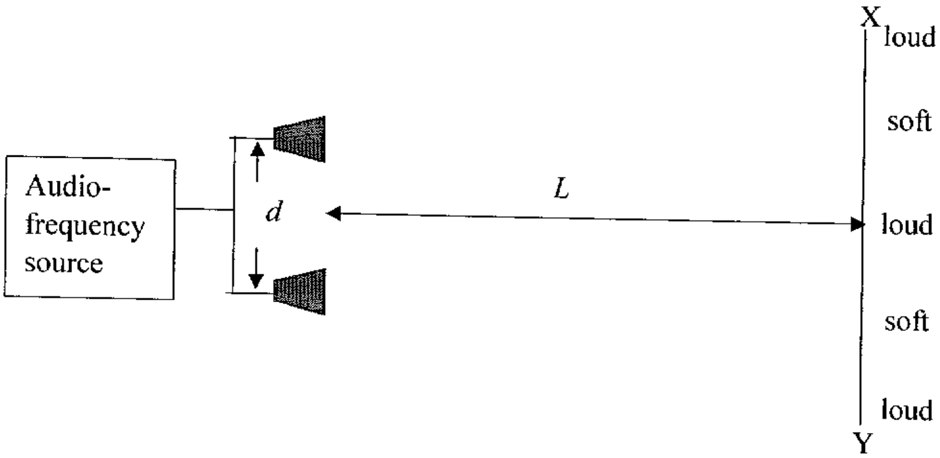


**Fig. 4.1**

The distance $L$ is much larger than the distance $d$. When a student walks with a constant speed from X to Y, the intensity of the note he hears is alternately loud and soft at equally spaced intervals.

**(a)** **(i)** Explain the origin of the loud and soft regions.

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**(ii)** The distance between the two loudspeakers is 75 cm while $L$ is 10.0 m. The sound has a wavelength of 4.8 cm. Calculate the distance between adjacent loud and soft regions.

[2]

**(iii)** While walking from X to Y, the student notices that the intensity of the maxima is not the same. It gets stronger when he walks from X towards the midpoint and then becomes weaker again as he walks towards Y. Explain his observations.

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**(b)** **(i)** When a recording is played through one of the loudspeakers, it is desirable that the speaker should have a diameter $d$ smaller than the wavelength. State the reason why.

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**(ii)** Estimate the maximum diameter of the speaker that would ensure adequate spreading of sound waves from a recording of a piano. Explain your reasoning. [Speed of sound in air = 340 m $s^{-1}$, the notes of a piano range from 34 Hz to 3.4 kHz.]

Maximum diameter = ..................... m [3]

5 **Fig. 5.1** shows the top view of two large, parallel metal plates P and Q. The plates are placed 10.0 cm apart in vacuum, with P at a potential of +12.0 V and Q at −12.0 V. Each plate has a length of 15.0 cm.

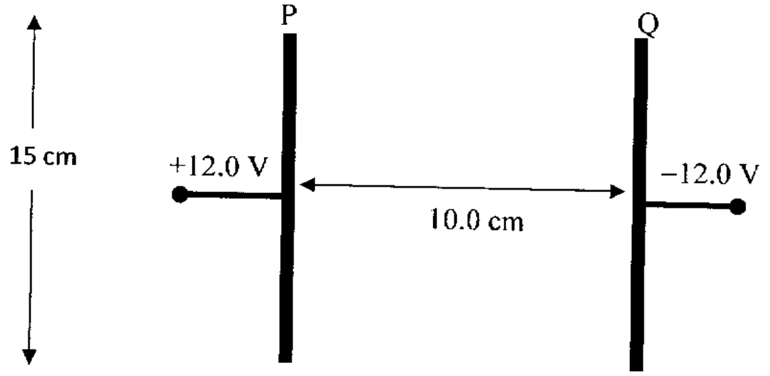


**Fig. 5.1 (plan view)**

(a) Draw, on **Fig. 5.1**, at least five arrows to represent the electric field inside the plates.

[1]

(b) A beam of electrons enters the field along a horizontal path, parallel to the plates and equidistant to the plates as shown in **Fig. 5.2**. Each electron has a velocity of $4.5 \times 10^6$ m $s^{-1}$.

(i) Show quantitatively that the electrons would clear the plates.

[4]

**(ii)** Sketch on **Fig. 5.2** the path of the electron beam between and beyond the plates. State an assumption made in drawing the path.

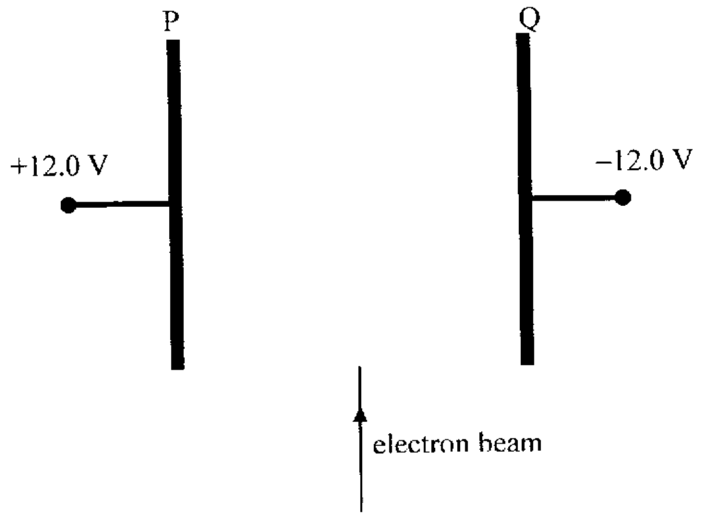


**Fig. 5.2 (plan view)**

Assumption: ...........................................................................

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**(c)** If a beam of protons were to enter the plates with the same velocity as the electrons in **Fig. 5.2**, state and explain whether they can clear the plates.

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6 (a) **Fig. 6.1** shows the famous Orion Nebula, which is a large gas cloud in the Milky Way. It contains many young stars being formed. The gas cloud produces vast quantities of energetic UV rays that ionise the surrounding gas. The ions eventually recombine, leaving the gas atoms in an excited state. The excited atoms subsequently return to their ground state.

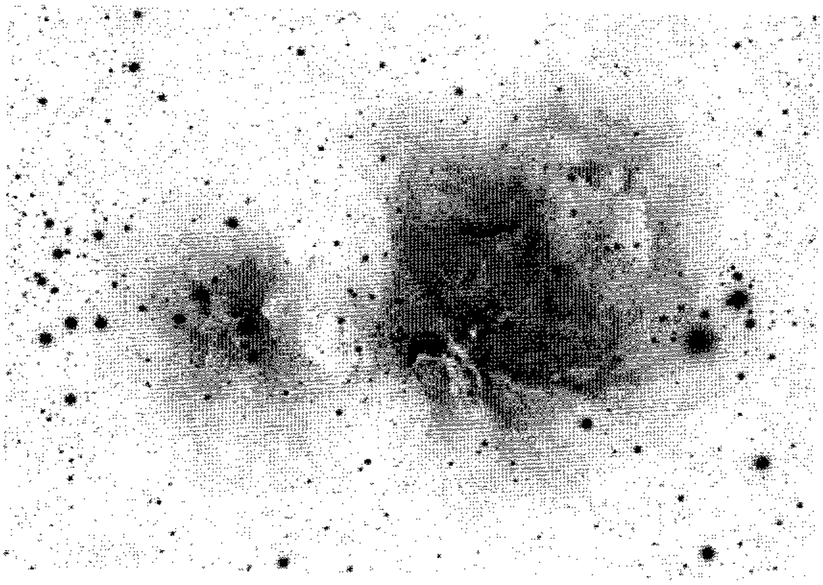

**Fig 6.1**

A simplified model of gas clouds is shown in **Fig. 6.2** below which depicts two different gas clouds. Cloud A is a hydrogen gas cloud in an excited state due to its proximity to a young star. Cloud B is a cool hydrogen cloud situated at a greater distance away and is not in an excited state.

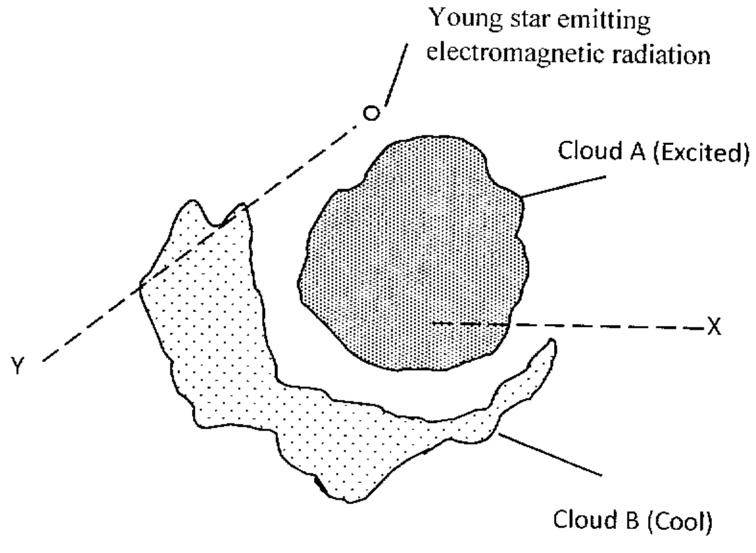


**Fig. 6.2**

(i) State and explain the type of hydrogen spectrum observed from point X along the dotted line.

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(ii) State and explain the type of hydrogen spectrum observed from point Y along the dotted line.

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(iii) Suggest how these observations provide evidence for discrete energy levels in atoms.

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**(b)** A metal target is bombarded by high-speed electrons. The spectrum of the emitted radiation is shown in **Fig. 6.3.**

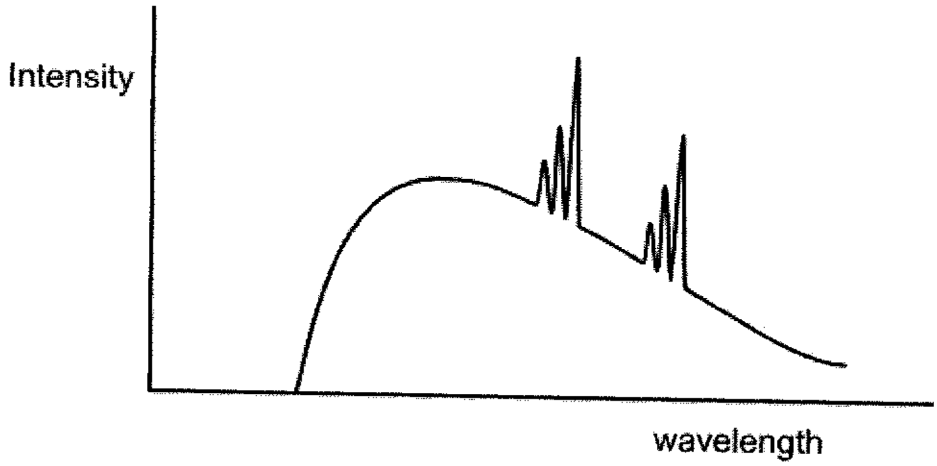


**Fig. 6.3**

(i) Explain why there is a continuous distribution of wavelengths.

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.......................................................................................... [2]

**(ii)** Consider now incoming electrons that have half as much kinetic energy as before. Sketch a curve on **Fig. 6.3** showing the new spectrum of the emitted radiation. [2]

## Section B

Answer **one** question from this Section in the spaces provided.

7

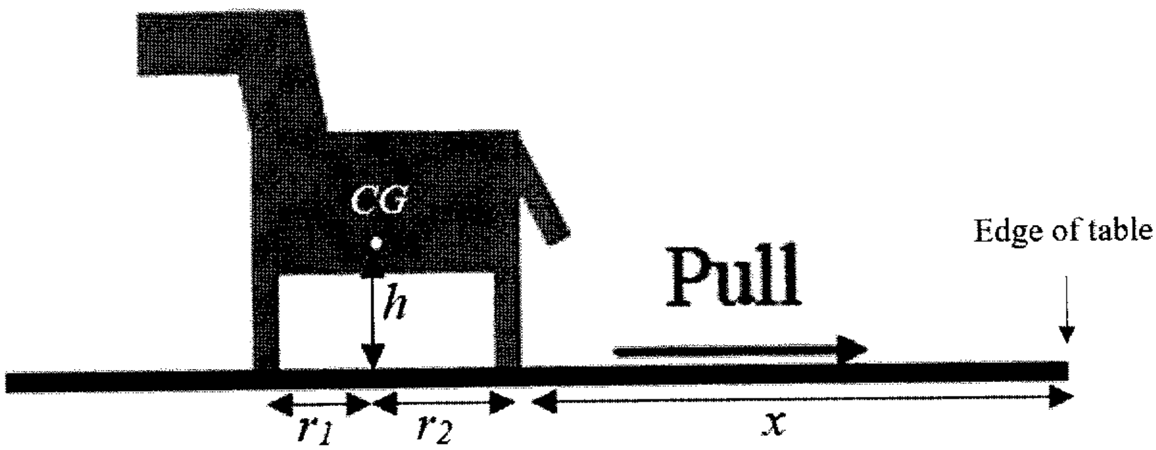


**Fig. 7.1**

A wooden toy horse rests on a tablecloth on a smooth table, with its back legs located at a distance $x = 0.300$ m from the edge of the table. It has a mass $m = 100$ g and its center of gravity (CG) is at distances $r_1 = 0.0500$ m from the front legs and $h = 0.0500$ m above ground. The distance between the front and back legs is 0.150 m. The coefficient of friction between the cloth and the horse is 0.750. The tablecloth is pulled horizontally.

**(a)** Describe a situation in which friction opposes motion and another in which it causes motion.

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**(b)** The cloth is pulled such that the horse is on the verge of slipping. The coefficient of friction $\mu$ is a dimensionless number defined as the ratio of frictional force to normal force exerted by one surface on another. Show that the frictional force $f$ between the cloth and the horse is approximately 0.736 N.

[2]

**(c)** Determine

**(i)** the acceleration of the horse relative to the table assuming the horse does not slip relative to the cloth.

Acceleration = .......................... m $s^{-2}$ [2]

**(ii)** the velocity of the horse when the back legs reach the edge of the table.

Velocity = ...................... m $s^{-1}$ [2]

(d) The table exerts a force $N_1$ and $N_2$ on the front and back legs of the horse respectively.

(i) Draw in and label all the forces acting on the horse in **Fig 7.1** as it is being pulled horizontally. Pay attention to the relative magnitudes of the vertical forces. [2]

(ii) Write down an expression to show

1. the vertical equilibrium of the horse

.................................................................. [1]

2. rotational equilibrium of the horse about its centre of mass while it is being pulled.

.................................................................. [1]

(iii) From your answers in **(ii)**, show that

$$N_2 = mg\frac{r_1 - \mu h}{r_1 + r_2}$$

[2]

(iv) Hence determine a value for $N_2$ and $N_1$.

$N_2$ = ......................... N [1]

$N_1$ = ......................... N [1]

(v) If the height of the center of gravity could be adjusted, determine the value above which the back legs of the horse would lose contact with the table.

Maximum height = ...................... m [2]

(vi) Apart from a low centre of gravity, suggest another two features which will make it less likely for the back legs of the horse to lose contact with the table.

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**(CLT – cancelled)**

**8** **(a)** Describe how two samples, one emitting alpha particles, and the other emitting beta particles can be distinguished through a simple school laboratory experiment, using a Geiger-Muller (GM) tube connected to a ratemeter.

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..........................................................................................[3]

**(b)** Radon (Rn) decays spontaneously with a half-life of 52 s to form polonium (Po) and polonium in turn decays spontaneously with a half-life of 0.16 s to form lead (Pb).

$$^{220}_{86}\text{Rn} \xrightarrow[52\text{ s}]{X} {}^{216}_{84}\text{Po} \xrightarrow[0.16\text{ s}]{} {}^{212}_{82}\text{Pb}$$

**(i)** Define the terms ***activity*** and ***decay constant***.

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..........................................................................................[2]

**(ii)** State the identity of the particle labelled **X** and write down the first decay equation in the series in (b).

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**(iii)** Suppose the activity of radon, Rn, is determined by measuring the number of particles X emitted. Explain how the decay of $^{216}_{84}Po$ will affect the measurement.

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..........................................................................................[3]

**(c)** Radioactive isotopes are often introduced into the body through the bloodstream. Their spread through the body can then be monitored by detecting the appearance of radiation in different organs. Iodine-131 ($^{131}I$), a beta emitter with a half-life of 8.04 days, is one such tracer. Suppose a scientist introduces a sample of $^{131}I$ with an activity of 375 Bq into the body and watches it spread to the organs.

**(i)** Discuss the difference between a photoelectron and a beta-particle by making reference to their origin.

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**(ii)** Assuming that all of the $^{131}I$ atoms in the sample went to the thyroid gland, calculate the decay rate in the thyroid 2.5 weeks later. Assume that none of the $^{131}I$ is eliminated by the body through physiological means.

Decay rate = ____________ Bq[3]

**(iii)** Calculate the mass of $^{131}I$ required to produce an activity of 375 Bq.

Mass = __________ kg[3]

**(d)** State one similarity and one difference between radioactive decay and nuclear fission.

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******** END OF PAPER ***********

**VICTORIA JUNIOR COLLEGE**

**SUGGESTED SOLUTIONS TO 2021 H2 PHYSICS PRELIM PAPER 3**

Q1(a)
Elastic PE = $\frac{1}{2} k x^2$
= $\frac{1}{2}(120)(10 \times 10^{-2})^2$
= **0.60 J**

Q1(b)
Using Law of Conservation of Energy, taking the lowest position of the box as correspondingto zero GPE,

$KE_i + GPE_i + EPE_i = KE_f + GPE_f + EPE_f$
$0 + (2.0)(9.81)(D \sin 40^0) + 0 = 0 + 0 + \frac{1}{2}(120)D^2$
$\boldsymbol{D = 0.210}$ **m**

*[Alternative: loss of GPE of box = gain in elastic PE of spring]*

Q1(c)
$D$ will increase.

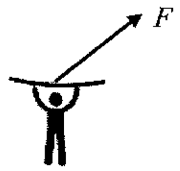
Q1(d)
Using Law of Conservation of Energy,
$KE_i + GPE_i + EPE_i = KE_f + GPE_f + EPE_f + W$ where $W$ = work done to overcome friction
$0 + (2.0)(9.81)(D' \sin 40^0) + 0 = 0 + 0 + \frac{1}{2}(120)D'^2 + (5.0)D'$
$\boldsymbol{D' = 0.127}$ **m**

*[Alternative: loss of GPE of box = gain in elastic PE of spring + work done to overcome friction]*

Q1(e)
A spring with a larger spring constant will be stiffer.

This will cause $D'$ to become smaller because the spring will stretch less.

Q2(a)

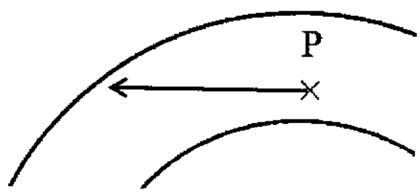



Q2(b)
The ceiling exerts a tangential force on the astronaut to increase the magnitude of his tangential velocity (tangential acceleration).

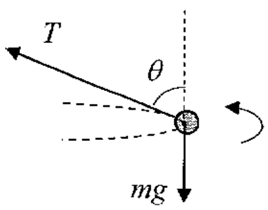
The ceiling also exerts a radial force on him to change the direction of his velocity (centripetal acceleration).

The resultant of the tangential and radial forces is a force that is inclined with respect to the radius.

Q2(c)




Q2(d)




Let $g$ = apparent acceleration (due to circular motion).
Net vertical force = 0
$T \cos\theta = mg$ …… (1)

Centripetal force = horizontal component of tension
$mr\omega^2 = T \sin\theta$
$m(L \sin\theta)\omega^2 = T \sin\theta$

$\therefore mL\omega^2 = T$

$mL\omega^2 = \frac{mg}{\cos\theta}$, using (1).

$g = L\omega^2 \cos\theta$

$$g = 0.958 \times \left(\frac{2\pi}{1.185}\right)^2 \times \cos 65.2^o$$

$\therefore g = 11.297$

$\therefore g =$ **11.3 m s$^{-2}$**.

Q2(e)

The acceleration found in (d) is the centripetal acceleration.

Centripetal force $= ma_c = mr\omega^2$

$mg = mr\omega^2$ or $g = r\omega^2$

$$\therefore 11.3 = r \times \left(\frac{2\pi}{14.2}\right)^2$$

$\therefore$ radius of circular motion of astronaut $= r$

$=$ **57.7 m**

Q3(a)

The First Law of Thermodynamics states that the internal energy $U$ of a system depends on its state, and the increase in internal energy $\Delta U$ is equal to sum of the heat supplied to the system $Q$ and work done $W$ on the system; i.e. $\Delta U = Q + W$.

Q3(b)

From the equation $p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$, the total kinetic energy or internal energy $U$ of an ideal gas can be expressed as

$K = \frac{1}{2}Nm < c^2 > = \frac{3}{2}pV$

From ideal gas equation, $pV = NkT$.

Hence $U = \frac{3}{2}NkT$

Q3(c)(i)1.

$U = \frac{3}{2}NkT = \frac{3}{2}PV$

$\Delta U = \frac{3}{2}P_C V_C - \frac{3}{2}P_B V_B$

$\frac{3}{2}(75.5\text{x}10^5)(4.54 - 2.27)\text{x}10^{-5}$

$= 257.08$ J

$\approx 257$ J

Q3(c)(i)2.

For a constant pressure process, work done $W$ by the gas in expeansion $= p\Delta V$.

Hence work done on the gas $= -p\Delta V$

$= -\ (75.5\text{x}10^5)(4.54 - 2.27)\text{x}10^{-5}$

**= -171 J**

Q3(c)(ii)

| Stage of cycle | heat supplied to gas / J | work done on gas / J | increase in internal energy of the system / J |
|---|---|---|---|
| A→B | 0 | 182 | 182 * |
| B→C | 428 * | -171 * | 257 |
| C→D | 0 | -316 | -316 * |
| D→A | -123 * | 0 * | -123 * |

Q4(a)(i)

When the waves arrive at the point of observation with a path difference of $n\lambda$, where $n$ =0,1,2,3…., they interfere constructively to give a loud note.

When the waves arrive at the point of observation with a path difference of $(n+\frac{1}{2})\lambda$, they interfere destructivly to give a soft note.

Q4(a)(ii)

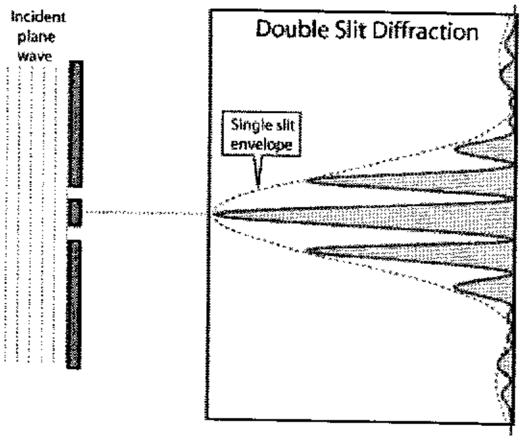
Using Young's double slit formula, the distance between two adjacent loud regions is $y = \frac{\lambda L}{d}$.

$$y = \frac{(4.8\text{x}10^{-2})(10)}{75\text{x}10^{-2}} = 0.64 \text{ m}$$

Hence the distance between an adjacent loud and soft regions is 0.64/2 = **0.32 m**

Q4(a)(iii)

The loudspeakers behave like double slits.




Waves from the double slits interfere to produce loud and soft regions at the points of observation.

Single slit diffraction from the aperture of a loudspeaker (each) forces the intensity regions to be confined within a diffraction envelope.

This produces an intensity profile that increases from X to centre and thereafter decreases to Y.

Q4(b)(i)

If the diameter $d$ of the loudspeaker is smaller than the wavelength $\lambda$ of sound, the latter will be able to diffract effectively through the loudspeaker.

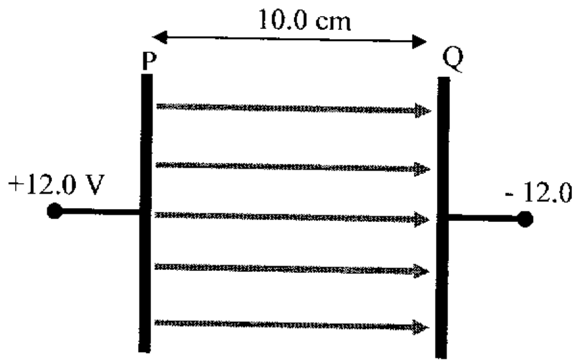
Q4(b)(ii)

The wavelength of sound is $\lambda = \frac{v}{f}$.

The wavelengths of notes from the piano range from 340/3400 to 340/34 m or 0.10 m to 10 m.

Hence $d < \lambda = \mathbf{0.10}$ **m** will ensure adequate spreading for all wavelengths.

Q5(a)




Q5(b)(i)

$E = \frac{\Delta V}{d} = \frac{12-(-12)}{10.0\text{x}10^{-2}}$

$= 240 \text{ V m}^{-1}$

Net Force $= Eq = ma$

$a = \frac{Eq}{m} = \frac{240 \times 1.6 \times 10^{-19}}{9.11 \times 10^{-31}} = 4.22 \times 10^{13} \text{ m s}^{-2}$

Time to cover 0.15 m of plate is

$t = \frac{0.15}{4.5\text{x}10^{6}} = 3.33 \text{ x } 10^{-8}\text{s}$

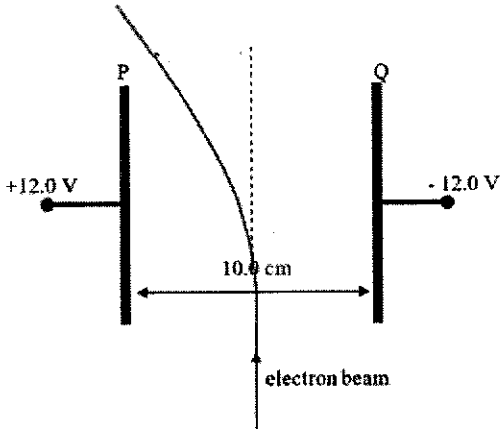
Using $s = ut + \frac{1}{2}at^2$ for the horizontal motion of the electron, we have

$s_x = \frac{1}{2}(4.22 \text{ x } 10^{13})(3.33 \text{ x}10^{-8})^2$

$= 0.0234$ m

Since this is smaller than 5.0 cm from midway between plates to a plate, the electrons will clear the plates.

Q5(b)(ii)




Assumption: Gravitational and magnetic field effects due to the Earth are negligible.

Q5(c)
The proton beam will be able to clear the plates.

The mass of the proton is much larger than an electron while its charge is the same magnitude as that of the electron. The proton will experience a smaller horizontal electric acceleration and will not deflect as much as an electron with the same velocity.

Q6(a)(i)
Emission spectral lines will be observed.

When atoms in excited states de-excite, energy is released in the form of photons. The photon energy is equal to the difference in atomic energy levels in the transition.This produces bright lines associated with the emitted photon wavelengths.

Q6(a)(ii)

Absorption spectral lines will be observed.

When electromagnetic radiation is incident on the cool gas, photons of energy that match the energy difference between an excited state and the ground state are absorbed by the atoms in the gas. The gas atoms then re-emit the photons in all directions,leaving dark lines of absorption in the spectrum.

Q6(a)(iii)
Both spectra consist of discrete frequencies which imply that the photons can only have particular energies.

Since atoms absorb or emit photons when electrons transit between energy states, this means that the energy levels must be discrete.

Q6(b)(i)
Continuous X-rays are produced by the slowing down of electrons when they interact with the positively charged nuclei of the metal target. The loss of KE is transformed into photon energy.

Different electrons impinging upon the metal target can have different amounts of interactions with target nuclei and hence have a distribution of decelerations. This leads to a continuous range of wavelengths produced.

Q6(b)(ii)
The new sketch should have smaller overall intensity but with the same characteristic wavelengths.

However, since the energy is halved, the cut-off wavelength is doubled.

Note:

$$E' = \frac{1}{2}E$$

$$\frac{hc}{\lambda'} = \frac{1}{2}\frac{hc}{\lambda}$$

$$\therefore \lambda' = 2\lambda$$

Q7(a)
A box sliding on a rough surface slows down because friction retards its motion.

A person walking on rough ground has a foot pushing the ground backwards. By

Newton's Third Law, the ground pushes the foot forward. The force responsible for the push is frictional in nature.

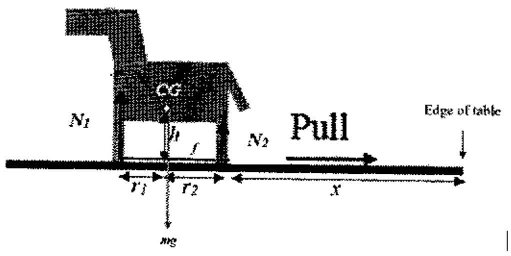
Q7(b)
For vertical equilbrium of horse, $N = mg$ where $N$ is the normal force .

$\mu = \frac{f}{N} \Rightarrow f = 0.750 \times 0.100 \times 9.81 = 0.7358$
$\approx 0.736$ N

Q7(c)(i)
N2L, $f = ma$
$a = \frac{0.7358}{0.100} = \mathbf{7.36}$ **m s$^{-2}$**

Q7(c)(ii)
Using "$v^2 = u^2 + 2as$"
We have $v = \sqrt{2ax} = \sqrt{2(7.358)(0.300)}$
$\approx$ **2.10 m s$^{-1}$**

Q7(d)(i)




Q7(d)(ii)1.

$$N_1 + N_2 = mg$$

Q7(d)(ii)2.

$$N_1 r_1 = N_2 r_2 + fh$$

Q7(d)(iii).
$(mg - N_2)r_1 = N_2 r_2 + fh$

$N_2 = \frac{mgr_1 - fh}{r_1 + r_2} = \frac{mgr_1 - \mu mgh}{r_1 + r_2}$

$\therefore N_2 = mg\frac{r_1 - \mu h}{r_1 + r_2}$

Q7(d)(iv)
$N_2 = (0.100)(9.81)\frac{0.0500 - 0.750(0.0500)}{0.150}$
$\approx$ **0.0818 N**

$N_1 = mg - N_2 = (0.100)(9.81) - 0.0818$
$\approx$ **0.899 N**

Q7(d)(v)
If the back legs of the horse lose contact with thetable, $N_2 = 0$.
$\therefore N_2 = mg\frac{r_1 - \mu h}{r_1 + r_2} = 0$ or $r_1 - \mu h = 0$
Hence $h = \frac{r_1}{\mu} = \frac{0.0500}{0.750} \approx$ **0.0667 m**

Q7(d)(vi)
Contact is maintained if $N_2 > 0$ or $r_1 - \mu h > 0$. Hence if $r_1 > \mu h$, the back legs of the horse will not lose contact with the table, i.e. have a big value for $r_1$.

Secondly, we can have a small value for $\mu$ i.e. the horse is pulled on a smooth cloth.
CLT topic removed on account of COVID-19.

******** END ********