NJOMBE REGION FORM SIX PRE-NATIONAL EXAMINATIONS 2024

131/1 **PHYSICS 1**

PROPOSED MARKING SCHEME

SECTION A (70 marks)

1. (a) (i) Understanding dimensions in physics provides a framework to analyze and solve problems by breaking down physical quantities into fundamental units. It helps discern relationships between different quantities, ensuring that equations and calculations remain consistent across various contexts……. (2 marks)

(ii) Dimensional analysis allows physicists to assess the validity of equations by ensuring that the dimensions on both sides of an equation match. This approach serves as a powerful tool to check the accuracy of derived equations and identify errors in problem solving process. It also facilitates the understanding of physical laws and principles by highlighting the fundamental relationships between different quantities. (4 marks)

(b) **Solution**

$T = 2\pi\sqrt{\frac{l}{g}}$

$(T)^2 = \left(2\pi\sqrt{\frac{l}{g}}\right)^2$

$T^2 = 4\pi^2.\frac{l}{g}$ $g = T\frac{4\pi^2 l}{T^2}$

Introduce Ln throughout

Ln g=Ln 4 +Ln π^2 +Ln l +LnT^2

=Ln 4+2Ln π +Ln l +2LnT……..… (01 mark)

Differentiate both sides

$\frac{\Delta g}{g} = \left(\frac{\Delta l}{l} + 2\frac{\Delta T}{T}\right)$…….…….. ($00\frac{1}{2}$ mark)

Given

$\Delta T = 0.1s$, T=2.22s, $g = 10ms^{-2}$ L=$(121.5 \pm 0.05)m$

But watch loses 2seconds on every 4 minutes

Now

2sec= (4x60) sec

ΔT_2 =2.22sec

cross multiplication, we get

$\Delta T_2 = \frac{2x2.22}{4x60}$=0.0185sec……..$\left(00\frac{1}{2}\text{ mark}\right)$

From

$\Delta T = \Delta T_1 + \Delta T_2$

= 0.1 +0.0185

$\Delta T = 0.1185sec$ …… $\left(00\frac{1}{2}\text{ mark}\right)$

Recall,

$\frac{\Delta g}{g} = \left(\frac{\Delta l}{l} + 2\frac{\Delta T}{T}\right)$

$\Delta g = \pm\left(\frac{0.05}{121.5} + 2\left(\frac{0.1185}{2.22}\right)\right)x10ms^{-2}$ …….. $\left(00\frac{1}{2}\text{ mark}\right)$

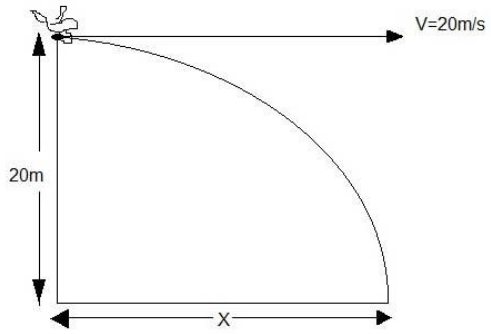
$\Delta g = \pm 1.07ms^{-2}$

∴ The error on measurement of acceleration due to gravity is $\pm 1.07ms^{-2}$

(01 mark)

2. (a) (i) Approach projectile motion by analyzing horizontal and vertical components using trigonometry and kinematic equations. Consider factors like initial velocity, launch angle and calculate parameters such as maximum height, range, time of flight and impact velocity for accurate solutions…… (2 marks)

Solution



…… $\left(00\frac{1}{2}\text{ mark}\right)$

Let X, be where the package strikes the ground.

For horizontal motion

$x = u_x t$

$= u_0 \cos\theta\, t$……..…… $\left(00\frac{1}{2}\text{ mark}\right)$

Since it is the horizontal motion, then $\theta = 0^0$

$x = u_0 \cos\theta\, t = \mu_0 t$

$x = u_0 t = 20t$…… (i) ……..……..….. (01 mark)

For vertical motion

$S = u_x t + \frac{1}{2} a_y t^2$ ……..…… $\left(00\frac{1}{2}\text{ mark}\right)$

where $S = -20\text{m}, a_y = -g$

$u_x = u_0 \sin 0^0 = 0$(since it is projected horizontally)

$-20 = -\frac{1}{2} gt^2$…….…… (00$\frac{1}{2}$ mark)

$t = \sqrt{\frac{2x20}{9.8}} = 2.02\text{sec}$ …… (00$\frac{1}{2}$ mark)

Now $x = 20x2.02 = 40.41\text{m}$

Therefore, the package strike the ground 40.41m away……. (00$\frac{1}{2}$ mark)

(b) (i) By moving his hands backward, a cricketer increases the time interval of impulse.

From Force $= \frac{\text{Impulse}}{\text{time}}$ .The result is that the force that acts on the hand becomes much smaller**.** ……..……..……. (01 mark)

(ii)

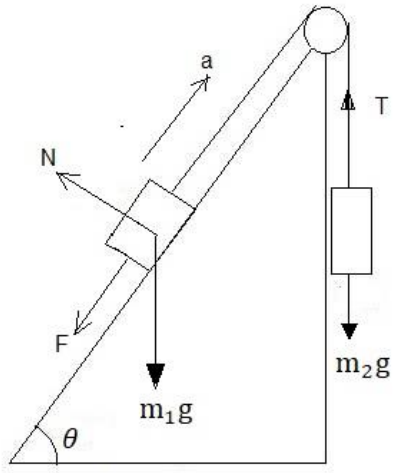


Figure 01

Assuming the direction of the masses is downward m_2

Friction force ; $f = m_1 g \cos\theta . \mu$

Net force for m_1

$T - m_1 g \sin\theta - f = m_1 a$…….. (i) $\left(00\frac{1}{2}\ mark\right)$

Net force for m_1

$m_2 g - T = m_2 a$…… (ii) $\left(00\frac{1}{2}\ mark\right)$

$Now\ solving\ for\ a,$ Acceleration in equation (i) and (ii)

$a = \frac{m_2 g - m_1 g sin\theta - f}{m_1 + m_2}$ But $f = m_1 g\, \mu \cos\theta .$

$a = \frac{m_2 g - m_1 g sin\theta - m_1 g\, \mu \cos\theta .}{m_1 + m_2}$ …….. $\left(00\frac{1}{2}\ mark\right)$

Given $m_1 = 0.05kg, m_2 = 0.03kg, \theta = 30^0, \mu = 0.032\ and\ g = 9.8m/s^2$

$a = \frac{(0.03x9.8) - (0.05x9.8xsin30) - (0.05x9.8x0.032)cos30}{0.05+0.03}$

$a = 1.181m/s^2$ …….. $\left(00\frac{1}{2}\ mark\right)$

From equation (ii) $m_2 g - T = m_2 a$, then; $T = m_2 g + m_2 a$

$T = (0.05x9.8) - (0.031x1.181) = 0.4546N$

Hence the acceleration and tension of the system of masses are $1.181m/s^2$ and 0.4546N respectively …….. (01 mark)

3. (a) (i) In order to balance the centripetal and centrifugal force. …… (1 mark)

(ii) The velocity is not constant because is a vector quantity and its direction keeps on changing. …… (2 marks)

(b) (i) Given Data

$m = 0.5kg$

$L = r = 1m$

$T = F_c = 50N$

$F_c = \frac{mv^2}{r}$

$v = \omega r$ …… $\left(00\frac{1}{2}\ mark\right)$

$F_c = m\omega^2 r$

But $\omega = 2\pi f$ …… $\left(00\frac{1}{2}\ mark\right)$

$F_c = 4\pi^2 f^2 mr$

$f^2 = \frac{F_c}{4\pi^2 mr}$ …… $\left(00\frac{1}{2}\ mark\right)$

$= \sqrt{\frac{F_c}{4\pi^2 mr}}$

$= \sqrt{\frac{50}{4\pi^2 x0.5x1}}$ …… $(01\ mark)$

$= 1.6rev/s \approx 2\ rev/s$ …… $\left(00\frac{1}{2}\ mark\right)$

(ii) Solution

Here T=27.3 days

T=27.3x24 60x60 sec (01 marks)

R=3.85x10^5 km (01mark)

R=3.85x10^8 m

But $a = \frac{v^2}{R} = r\omega^2 = r(\frac{2\pi}{T})^2$ (01mark)

Acceleration (a) =2.73x10^{-3}ms^{-2} (01mark)

4. (a) It meant that $6.5x10^5$Joules of energy is required on the surface of the earth to send the body outside the gravitational field of the earth ……(04 marks)

(b) solution

From

$mg' = mg - mR\omega^2 cos^2\lambda$ (01 mark)

But $mg' = \frac{3}{4}\ mg$ and λ =60° (01 mark)

$\frac{3}{4}mg = mg - mR\omega^2 cos^2\lambda$ (01 mark)

$\frac{1}{4}mg = mR\omega^2 cos^2\lambda = mR\omega^2(\cos 60)^2$ (01 mark)

$\frac{1}{4}mg = \frac{mR\omega^2}{4}$ (01 mark)

$\omega = \sqrt{\frac{g}{R}}$

$\omega = \sqrt{\frac{9.8}{6400000}}$

ω =1.24x10^{-3} rad/sec (01 mark)

5. (a) (i) This is because they establish reference points for scales measurement. The fixed points provide a basis for calibrating the scale, ensuring consistency and accuracy in temperature measurements across different systems and instruments. … ..(02 marks)

(ii) Answers:

- Gas thermometer.-
- Advantage. It is very accurate, wide temperature range.

- Disadvantage. It is not easily portable. Fragility: Gas thermometers can be fragile and sensitive to external conditions such as changes in pressure and handling which may affect their accuracy and reliability over time. …….. (3 marks)

(b) (i) In cold countries, windows of modern buildings are double glazed to enhance insulation. Double glazing involves two layers of glass with a gap between them, which reduces heat transfer, minimizes condensation, thus increasing energy efficiency and comfort in cold climate……. (2 marks)

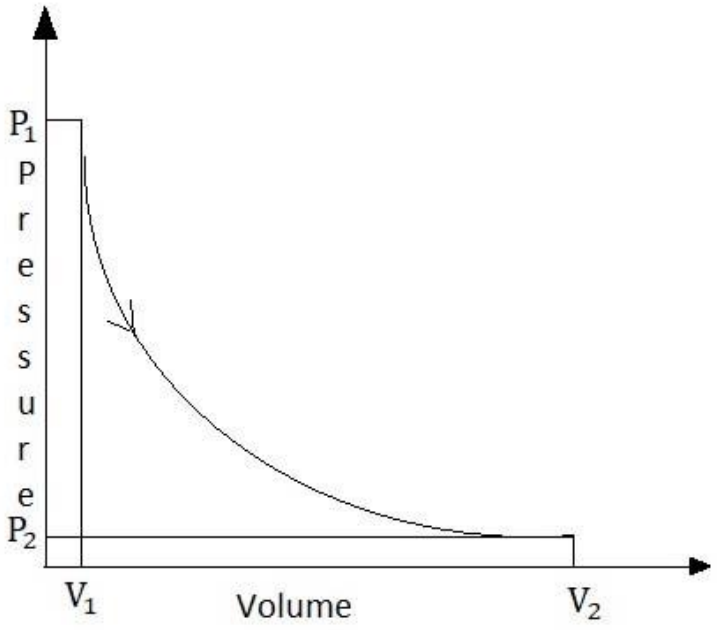
(ii) The power radiated by a blackbody is proportional to the fourth power of its temperature and directly proportional to the surface area. When the radius is halves, the surface area is reduced by a factor of 4. When the temperature is doubled, the power is increased by a factor of 16. Therefore, when the radius is halved and the temperature is doubled, the power radiated would be $450x\frac{16}{4} = 1800W$... (3 marks)

6. (a) (i) It's preferred to purchase cooking utensils with low specific heat capacity because they heat up quickly and distribute heat evenly, allowing for more efficient cooking and temperature control ……. (3 mark)

(ii) Fish can survive in a frozen pond during winter because the ice insulates the water below. Keeping it from freezing solid. This allows fish to stay in the unfrozen water and continue to breath oxygen from it……. (3 marks)

(b) Solution

PV graph



(01 mark)

The heat taken in when a gas expands isothermally is the heat equivalent to the work done. If the volume of the gas increases by a small amount ΔV at the pressure P, then the work done is :-

$\Delta W = P\Delta V$

In an expansion from V_1 to V_2, therefore, the work done is

$W = \int dw = \int_{V_1}^{V_2} pdv$ …… …. (01 mark)

Since $PV = nRT, then\ P = \frac{nRT}{V}$…….…... (01 mark)

$\therefore\ W = \int_{V_1}^{V_2} pdv = \int_{V_1}^{V_2} \frac{nRT}{V} \mathrm{dv} = \mathrm{nRT} \int_{V_1}^{V_2} \frac{dv}{v}$

$= nRT[LnV]_{V_1}^{V_2} = nRT(Ln\, V_2 - V_1)$

$\mathrm{W} = nRTLn\left[\frac{V_2}{V_1}\right]$

The heat Q is therefore:- $Q = W = nRTLn\left[\frac{V_2}{V_1}\right]$……. (01 mark)

7. (a) The velocities of both P and S- waves are influenced by:

(i) Density of the rock material (media)……... (02 marks)

(ii)Modulus of elasticity …….... (02 marks)

(b) Speed is the characteristic property of seismic waves that is used to locate discontinuities. Between the crust and mantle there is abrupt change of density, which shows an abrupt change in speed of both P- and S-waves, a Mohorovicic discontinuity exists here. Both P-

and S-waves travel across this discontinuity. …….… (06 marks)

SECTION B (30 marks)

8. (a) Solution

$q = at - \frac{1}{2}bt^2 + \frac{1}{6}ct^3$

Differentiate q w.r.t. time (t)

$\frac{dQ}{dt} = a - bt + \frac{1}{2}at^2$

$I = a - bt + \frac{1}{2}at^2$ (01mark)

(i) Initial current, $t = 0$ $I = a$ (01mark)

(ii) The time after which the current reaches the maximum value

Differentiate I w.r.t time (t)

$\frac{dI}{dt} = -b + ct$

When the current reaches its maximum value, then $\frac{dI}{dt} = 0$

$0 = -b + ct$

$ct = b$

$t = \frac{b}{c}$ (02mark)

(iii) The maximum or minimum value of current.

$I = a - bt + \frac{1}{2}at^2$

Substitute the value of time, t above in the equation $I = a - b.\frac{b}{c} + \frac{1}{2}c.\frac{b^2}{c^2}$ ...

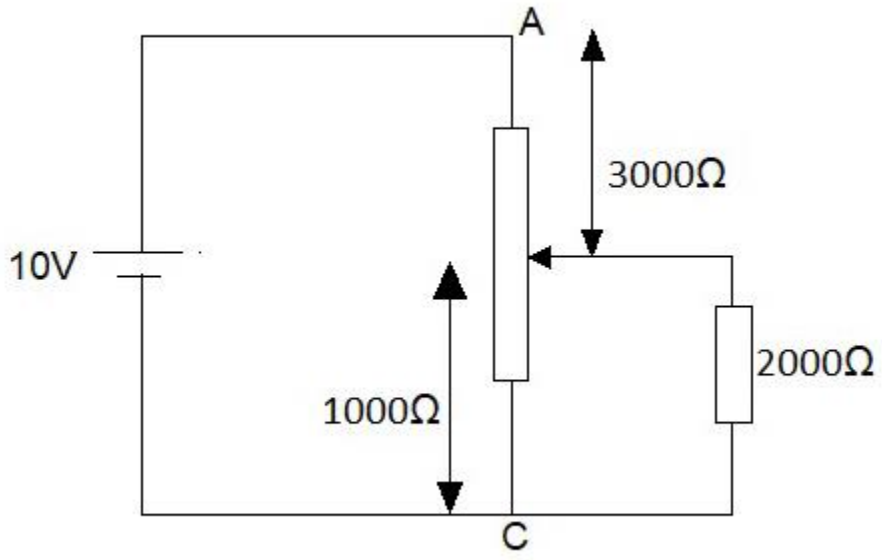
$I = a - \frac{b^2}{C} + \frac{b^2}{2C}$

$I = a - \frac{b^2}{2C}$

Above is a minimum value since it is less than the value at $t = 0$ (02mark)

(b) (i) Solution

Consider the circuit below



One quarter of 4000Ω is 1000Ω

$\mathbf{V = \left(\frac{1000//2000}{1000//2000\ +3000}\right) x10V}$**…….** **(01 mark)**

$\mathbf{= \left(\frac{2000/3}{2000/3\ +3000}\right) x10V=1.82V}$**……** **(01 mark)**

(ii) Half way of 4000Ω is 2000Ω

$\mathbf{V = \left(\frac{2000//2000}{2000//2000\ +2000}\right) x10V}$ **……** **(01 mark)**

$\boldsymbol{V = \left(\frac{1000}{1000+2000}\right) x10}$

=3.3V …… **(01 mark)**

(c) (i) Node is a junction in the circuit where by current meets or leave the circuit.

(01 mark)

(ii) $\mathbf{15 - 9 - 3I - 6I = 0}$ ……. (01 mark)

$\mathbf{-9I = -6}$

$\mathbf{I = \frac{2}{3}A}$……. (01 mark)

$\mathbf{V = 9 + IR}$

$\mathbf{V = 9 + \left(\frac{2}{3}\right)6}$ ……. (01 mark)

$\mathbf{= 9 + 4}$

$\therefore$ **The reading of Voltimeter (v)is =13V**…… (01 mark)

9. (a) (i)

- Silicon is easily available ……..…….. (01 mark)
- Silicon is less expensive ……..…….. (01 mark)
- Silicon has smaller linkage current…...……..…….. (01 mark)

(ii) Leakage current is a current that flows in a device when it is not connected to sources of power. …… (01 mark)

(b) (i) The property of a semiconductor diode that permits it to be used as a rectifier is its ability to conduct current in only one direction while blocking current flow in the opposite direction. This property is called "Unidirectional conductivity" or rectification……..……. (03 marks)

(ii) $E = V_{D1} + V_{D2} + V_{R2}$

$E = V_{D1} + V_{D2} + I_2R_2$

$I_2 = \frac{E - V_{D1} - V_{D2}}{R_2}$ …… $\left(00\frac{1}{2}\ mark\right)$

$I_2 = \frac{20 - 0.7 - 0.7}{5600}$

$I_2 = 3.3mA$ …… $\left(00\frac{1}{2}\ mark\right)$

$V_{D2} = I_1R_1$

$I_1 = \frac{V_{D2}}{R_1}$ $I_1 = \frac{0.7}{3300} = 0.212\text{mA}$ ..... (01 *mark*)

$I_2 = I_{D2} + I_1$

$I_{D2} = I_2 - I_1$

$I_{D2} = 3.32 - 0.212 - I_1$

$I_{D2} = 3.108\text{A}$ ..... (01 *mark*)

(c) (i) Solution

Calculate I_E in a transistor for which $\beta = 50$ and I_B=20μA.

$\beta = \frac{I_c}{I_B}$ $I_C = \beta I_B$..... $\left(00\frac{1}{2}\text{ mark}\right)$

$I_C = 50\text{x}20\text{x}10^{-6}$

$I_C = 1\text{mA}$ ..... $\left(00\frac{1}{2}\text{ mark}\right)$

$I_E = I_B + I_C$ ..... $\left(00\frac{1}{2}\text{ mark}\right)$

$I_E = 20\text{x}10^{-6} + 1\text{x}10^{-3}$

$I_E = 1.02\text{mA}$ ..... $\left(00\frac{1}{2}\text{ mark}\right)$

(ii) Solution

Given Data

$V_{cc} = 10\text{V}$, $I_C = 1\text{mA}$

- When collector load $R_c = 5\text{k}\Omega$,

  then. $V_{CE} = V_{CC} - I_C R_C$ ..... $\left(00\frac{1}{2}\text{ mark}\right)$

  =10 −1mAx4kΩ

  =10-4=6V ..... $\left(00\frac{1}{2}\text{ mark}\right)$

  ∴ Operating point is 6V, 1mA .....(01 mark)

- When collector load $R_C = 5k\Omega$,

  then $V_{CE} = V_{CC} - I_C R_C$ ..... $\left(00\frac{1}{2}\text{ mark}\right)$

  =10 −1mAx5kΩ

  =10-5=5V

  ∴ Operating point is 5V, 1mA ..... $\left(00\frac{1}{2}\text{ mark}\right)$

10. (a) (i) A comprehensive approach would involve defining the problem, selecting appropriate compounds, creating a logical circuit design, optimizing for efficiency and testing the prototype to ensure it meets the desired functionality. …….. (3 marks)

(ii) NOR gates are integrated to burglar alarm circuits because they produce a high output only when all inputs are low, allowing for efficient triggering of the alarm system when specific security conditions are met. …….. (3 marks)

(b) (i) Inverting OP-Amp: The input signal is applied to the inverting (-) terminal of the OP-Amp and the output signal is inverted compared to the input signal. ….. (1 mark)
Non-Inverting OP-Amp: The input signal is applied to the non-inverting (+) terminal of the op-amp and the output signal is not inverted compared to the input signal... (1 mark)

(ii) Inverting OP-Amp: Application: Are commonly used in signal processing applications, such as audio amplifiers. They can also be used for voltage followers and active filters. …….. (01 mark)
Non -Inverting OP-Amp: Application: Non- inverting amplifiers are often used in voltage follower configurations to buffer and amplify signals without inverting their phase. They are also utilized in audio amplifiers, voltage regulators and impedance matching……..…….... (01 mark)

(c) (i) Three basic elements of communication system are:

- Transmitter ……..…….(01 mark)
- Channel……....(01 mark)
- Receiver ……..……....(01 mark)

(ii) Sideband frequency=Carrier frequency $\pm$ Modulating frequency
So Sideband frequency=500Hz $\pm 1kHz$
So, lower Side Band (LSB) =$-$500Hz and Upper Side Band (USB) =1500Hz. (01 mark)

Negative frequency does not exist, so we ignore it.
The bandwidth required for this modulation scheme is twice the highest sideband frequency, so

Bandwidth=2x1500Hz=3000Hz

= 3kHz…… (01 mark)