END OF SECOND TERM 2024_DISTRICT EXAMINATIONS

PHYSICS II_MARKING GUIDE

SECTION A: ATTEMPT ALL QUESTIONS (70MARKS)

Q1.	Q2.	Q3.	Q4.	Q5.
D **(1 mark)**	B **(1 mark)**	C **(1 mark)**	D **(1 mark)**	B **(1 mark)**

Q6.	(a)	(b)	(c)	(d)
	False **(1 mark)**	True **(1 mark)**	False **(1 mark)**	True **(1 mark)**

Q7. a) Wien's displacement law states that the black body radiation curve for different temperatures will peak at different wavelengths that are inversely proportional to the temperature. **(1 mark)**

Or $\lambda_{peak} = \frac{b}{T}$ (Wien's law)

b) **-**It states that light travels in bundles/packets of energy, and each bundle is known as a quantum, in case of light this is photon. **(1 mark)**

- The matter is composed of a larger number of oscillating particles. These oscillators have different frequencies. **(1 mark)**

OR: -Each photon carries a quantity of energy equal to the product of the frequency of vibration of that photon and Planck's constant. E_{photon} = hf.

-Matter radiates energy absorbs energy in discrete, discontinuously in the form of quantum.

c) The Wave- Particle Duality states that light can exhibit particle-like properties and exhibit wave-like properties. **(1 mark)**

d) P = E/C **(1 mark)** where p is momentum and E is energy of the photon C is speed of light in vacuum.

Q8. This statement is true **(1 mark).** The motion that repeats itself at regular intervals of time is called periodic motion **(1 mark)**. Example: The motion of the hands of the clock **(0.5 marks)**, the motion or the planets around the Sun are periodic motions.

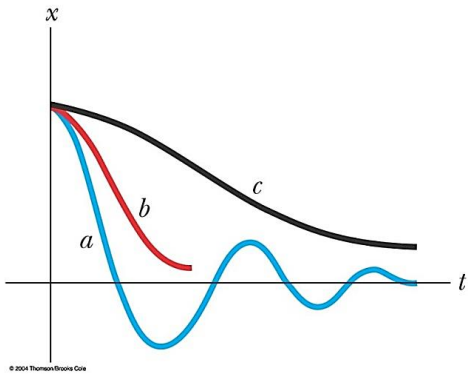
If the periodic motion is linear and the acceleration of the particle executing the potion is proportional to its displacement from the position of equilibrium and is always directed towards the mean position, the motion is said to be simple harmonic motion **(1 mark)**. Example: oscillating pendulum **(0.5 marks)**

Q9. a) (-) Light damping /under damped oscillation **(1 mark)**

(-) Critical damping/critically damped oscillaton (**1 mark)**

(-) Heavy damping/ over damped oscillation **(1 mark)**

Their curves:



/(3 marks)

b) (i) It decreases exponentially the amplitude as time advances **(1 mark)**
(ii) Resonance occurs when the driving frequency of a forced oscillation matches the natural frequency of a system ($\omega_e = \omega_0$) giving rise to large amplitude. **(1 mark)**

Q10. A stationary wave is formed by a superposition of equal of equal progressive wave travelling in opposite direction whereas a progressive wave is formed due to continuous vibration of the particle of the medium. **(1 mark)**

The wave does not travel in any direction in stationary waves whereas, in progressive waves, the wave travels with a certain velocity. **(1 mark)**

There is no flow of energy in stationary whereas in progressive waves there is a flow of energy.

(1 mark)

Particles at node are at rest in stationary waves whereas in progressive waves no particles in the medium are at rest. **(1 mark)**

In stationary waves, all particles in a loop are in the same phase and they are in opposite phase with respect to particles in adjacent loops, whereas in progressive waves, phase change continuously from particle to particle.

Q11. L=3m

a) $\mu = 0.0025kg/m$

$f_n = 252H_z$ and $f_{n+1} = 336H_z$

$$\begin{cases} f_n = nf_1 \ldots . (1) \\ f_{n+1} = (n+1)f_1 \ldots \ldots . (2) \end{cases}$$

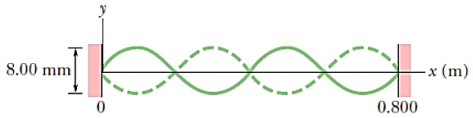
Take (2)-(1):$f_{n+1} - f_n = f_1$ **(1 mark)**

therefore $\boldsymbol{f_1 = 336Hz - 252Hz = 84H_z}$ **(1 mark)**

b)From fundamental frequency, $f_1 = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$ **(1 mark)**

$implies\ T = 4L^2 {f_1}^2 \mu$ **(1 mark),** therefore $\boldsymbol{T = 635.04N}$ **(1 mark)**

Q12. a) The traverse waves that produce a standing wave pattern must have a wavelength such that an integer number n of half-wavelengths fit into the length L of the string.



$$2\lambda = L \Leftrightarrow \lambda = \frac{L}{2} = \frac{0.800\,m}{2} = 0.400\,m \qquad \text{(2 marks)}$$

b) By counting the number of loops (or half-wavelengths) in Fig. above, we see that the harmonic number is $n = 4$. We also find $n = 4$ by comparing Eqs. $\lambda = \frac{L}{2}$ and $\lambda = \frac{2L}{n}$. Thus, the string is oscillating in its fourth harmonic **(1 mark)**

c) The speed *of* the waves $v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{TL}{m}} = \sqrt{\frac{(325\,N)(0.800\,m)}{2.50\times10^{-3}\,kg}} = 322.49\,m/s$ (2 marks)

The frequency of those waves and of the oscillations of the string elements is given by Eq.

$$f_4 = \frac{v}{\lambda} = \frac{322.49\,m/s}{0.400\,m} = 806.2\,Hz = 806\,Hz \quad \text{(2 marks)}$$

Q13. a) The electric potential at point P :

From $V_P = \frac{kQ}{r}$ **(1 mark)**

$$V_P = \frac{(9x10^9\,Nm^2/C^2)(9x10^{-6}C)}{0.6m} = 1.35x10^5 V \textbf{ (1 mark)}$$

b) The work done to bring the point charge from infinity to point P**:**

From $W = Q(V_P - V_\infty)$ **(1 mark)**

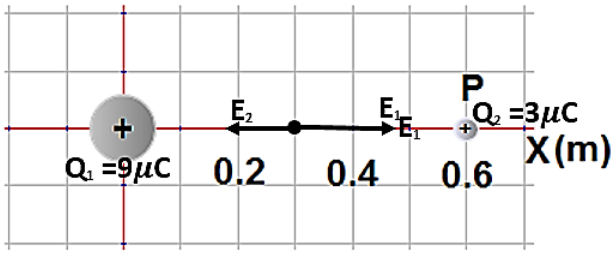
$W = 3x10^{-6}C(1.35x10^5 V - 0) = 0.405J$ **(1 mark)**

c) The electric force between two charges: $F = k\frac{Q_1 Q_2}{r^2}$ **(1 mark)**

$$F = \frac{(9x10^9\, Nm^2/C^2)(9x10^{-6}C)(3x10^{-6}C)}{(0.6m)^2} = 0.675N \quad \textbf{(1 mark)}$$

d) The net electric field at point 0.3 m from the origin: $E = k\frac{Q}{r^2}$ **(1 mark)** implies

$$E = k\left[\frac{Q_1}{r_1^2} + \frac{Q_2}{r_2^2}\right] = \frac{k}{r^2}\left[Q_1 + Q_2\right] \; because \; r_1 = r_2 = 0.3m$$



$$E = \frac{(9x10^9\, Nm^2/C^2)}{(0.3m)^2}\left[(9-3)x10^{-6}C\right] = 6.0x10^5\, N/C \quad \textbf{(1 mark)}$$

e) The speed of the point charge when it is far away from the origin:

From $K.e = \frac{1}{2}mv^2 = QV_P$ **(1 mark)**

$$v = \sqrt{\frac{2QV_P}{m}} = \sqrt{\frac{2x(3x10^{-6}C)(1.35x10^5V)}{(5x10^{-3}kg)}} = 12.7m/s \quad \textbf{(1 mark)}$$

Q14. a) (i) the emf of the resultant battery is 2 V **(1 mark)**

(ii) the internal resistance of the resultant battery

$r_t = \frac{r}{n}$ **(1 mark)** *implies* $r_t = \frac{0.5}{5}$, therefore , $r_t = 0.1\Omega$ **(1mark)**

(iii) $I = \frac{\varepsilon}{R + r_t}$ **(1 mark)** *implies* $\mathrm{I} = \frac{2\mathrm{V}}{1.1\Omega + 0.1\Omega}$ therefore, $I = 1.67A$ **(1 mark)**

b) (i) After applying Kirchhoff's voltage law, $V = 14\mathrm{V}$ **(2 marks)**

(ii) After applying Kirchhoff's current law, $I_{4\Omega} = 3A$ **(1mark)**

(iii) After applying Kirchhoff's voltage law, $\mathrm{R} = 5\Omega$ **(2 marks)**

Q15. a) Every massive particle in the Universe attracts every other massive particle with a force directed along the line of centres for the two massive particles that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

(1 mark)

b) (i) **-1st Law: (This law is called the law of orbits):**

The planets describe ellipses about the sun as one focus. **(0.5 mark)**

-2nd Law: (This is called the law of areas):

The line joining the sun and the planet sweeps out equal areas in equal periods of time. **(0.5 mark)**

-3rd Law: (The law of periods):

The square of the periods T of revolution of planets are proportional to the cubes of their mean distances R from the sun. $T^2 \propto R^3$.

(ii) Kepler's laws of planetary motion important to Astronomy since they explain the movements of the planets, stars, and other celestial bodies. **(1 mark)**

c)(i) $r = R + h$ **(1 mark)** $implies r = 6400 + 700 = 7.1 \times 10^6\, m$ **(1 mark)**

(ii) The speed of a satellite orbiting around the earth is given by $G\frac{Mm}{r^2} = \frac{mv^2}{r}$

$$v = \sqrt{\frac{GM}{r}} \quad \textbf{(1 mark)}$$

$$v = \sqrt{\frac{6.67\times10^{-11}\times5.97\times10^{24}}{7.1\times10^{6}}} = \boldsymbol{7489 m/s} \quad \textbf{(1 mark)}$$

(iii) The gravitational field strength in the region of the satellite: $g = \frac{GM_E}{(R_E+h)^2}$ **(1 mark)**

SECTION B: ANSWER ONLY THREE QUESTIONS (30MARKS)

Q16. a) Fission **(1 mark)**

b) Plutonium **OR** Uranium **(1 mark)**

c) $E \rightarrow B \rightarrow C \rightarrow G \rightarrow D \rightarrow A \rightarrow F$ **(6 marks)**

d) Any 2 from: **(1 mark)**

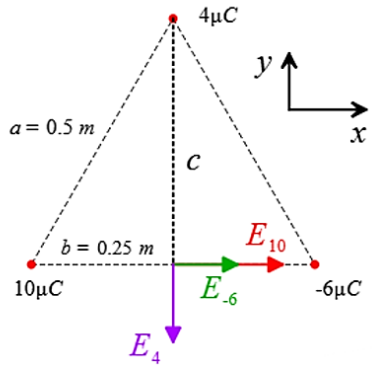
- Risk of radioactive material escaping into environment
- Products of nuclear fission are radioactive
- Many isotopes produced have long half-lives
- Reactors can be used to produce material for nuclear weapons

e) Efficiency refers to the quality of working well in an organized way, without wasting time or energy **(1 mark)**

Q17. An equilateral triangle is a triangle that has all sides and angles equal. In this question, we are asked to find the net electric field midway on the *x*-axis.

The calculation of the magnitude of the electric field at a point between the charges on the *x*-axis is straight forward.

*Step 1: **Free body diagram:** **/(3 marks)**



*Step 2: **Finding Magnitudes**

Formula to be used $\boldsymbol{E = k\frac{|Q|}{r^2}}$

To find the electric field due to the charge 4μC, we need to determine the distance to the desired/interested point.
According to the Pythagorean theorem, we can find this distance, denoted as *c*, as follows

$$c = \sqrt{a^2 - b^2} = \sqrt{(0.5)^2 - (0.25)^2} = 0.43\text{m}$$

$$E_4 = 9 \times 10^9 \frac{|4\times10^{-6}|}{(0.43)^2} = 0.19 \times 10^6 N/C \qquad \textbf{(1mark)}$$

$$E_{-6} = 9 \times 10^9 \frac{|-6\times10^{-6}|}{(0.25)^2} = 0.86 \times 10^6 N/C \qquad \textbf{(1mark)}$$

$$E_{10} = 9 \times 10^9 \frac{|10\times10^{-6}|}{(0.25)^2} = 1.44 \times 10^6 N/C \qquad \textbf{(1mark)}$$

*Step 3: **Finding Components on both axes**

$$E_{net-x} = E_{4x} + E_{-6x} + E_{10x} = (0 + 0.86 + 1.44) \times 10^6 = 2.30 \times 10^6(\vec{\imath})\ N/C \qquad \textbf{(1mark)}$$

$$E_{net-y} = E_{4y} + E_{-6y} + E_{10y} = (-0.19 + 0 + 0) \times 10^6 = -0.19 \times 10^6(\vec{\jmath})\ N/C \qquad \textbf{(1mark)}$$

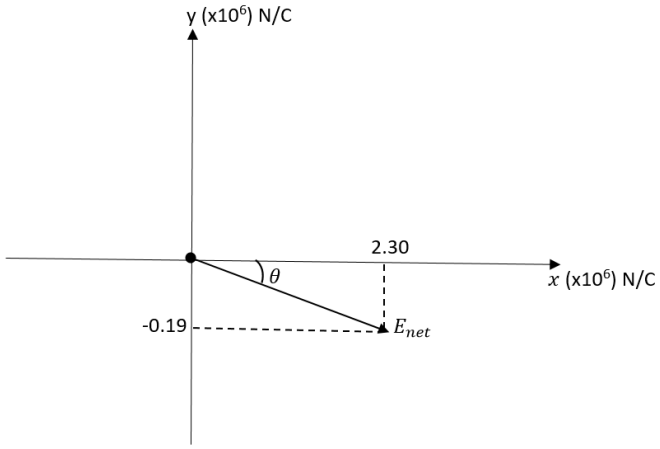
*Step 4: **Finding the magnitude of E_{net}** at the desired point:

$$E_{net} = \sqrt{(E_{net-x})^2 + (E_{net-y})^2}$$

$$E_{net} = \sqrt{(2.30 \times 10^6)^2 + (-0.19 \times 10^6)^2}$$

$$\boldsymbol{E_{net} = 2.31 \times 10^6 N/C} \qquad \textbf{(1mark)}$$

*Step 5: **Finding Direction of** E_{net}



$tan\theta = \frac{E_{net-y}}{E_{net-x}} = \frac{-0.19\times10^6}{2.30\times10^6}$ which yields $\theta = \mathbf{-4.72°}$

Therefore E_{net} is located at $4.72°$ angle below $+x_axis$ in the fourth quadrant. **(1mark)**

Q18. a) $\boldsymbol{\Delta x = x_2 - x_1 = dsin\theta}$ **(1mark)**

b) **(i)** $Y_p = a[sin\omega t + sin(\omega t + \varphi)]$

Or $sinp + sinq = 2cos\left(\frac{p-q}{2}\right)sin(\frac{p+q}{2})$ **(1mark)**

As , $\frac{\omega t-\omega t-\varphi}{2} = -\frac{\varphi}{2}$ *and* $\frac{\omega t+\omega t+\varphi}{2} = \omega t + \frac{\varphi}{2}$

$$\boldsymbol{Y_p = 2acos(\frac{\varphi}{2})sin(\omega t + \frac{\varphi}{2})}$$ **(1mark)**

(ii) Phase difference is directly proportional to the path difference. **(1mark)**

Or $\Delta\varphi = k.\Delta x = k(x_2 - x_1) = \boldsymbol{\frac{2\pi}{\lambda}dsin\theta}$

(iii) -Condition for constructive interference:

$$2acos\left(\frac{\varphi}{2}\right) = \pm 2a$$

$$cos\left(\frac{\varphi}{2}\right) = \pm 1$$

$$cos\left(\frac{\varphi}{2}\right) = cos(n\pi)$$

$$\varphi = 2n\pi$$

$$\frac{2\pi}{\lambda}dsin\theta = 2n\pi$$

$$\boldsymbol{dsin\theta = n\lambda}$$ **/(1 mark)**

-Condition for destructive interference:

$$2acos\left(\frac{\varphi}{2}\right) = 0$$

$$cos\left(\frac{\varphi}{2}\right) = 0$$

$$cos\left(\frac{\varphi}{2}\right) = cos\left[(2n+1)\frac{\pi}{2}\right]$$

$$\varphi = (2n+1)\pi$$

$$\frac{2\pi}{\lambda} dsin\theta = (2n+1)\pi$$

$$\boldsymbol{dsin\theta = (2n+1)\frac{\lambda}{2} = \left(n+\frac{1}{2}\right)\lambda} \quad \textbf{/(1 mark)}$$

(iv) -Position of the bright fringes: $dsin\theta = n\lambda = \frac{yd}{D}$

$$\boldsymbol{y_{nB} = n\frac{\lambda D}{d}} \quad \textbf{/(1 mark)}$$

-Position of the dark fringes: $dsin\theta = (2n+1)\frac{\lambda}{2} = \left(n+\frac{1}{2}\right)\lambda = \frac{yd}{D}$

$$\boldsymbol{y_{nD} = (n+\frac{1}{2})\frac{\lambda D}{d}} \quad \textbf{/(1 mark)}$$

c) $d = 100\lambda \quad and\ D = 0.5m$

$$y = \frac{\lambda D}{100\lambda} \quad \textbf{/(1 mark)}$$

$$y = \frac{D}{100} = \frac{0.5m}{100}$$

$$\boldsymbol{y = 0.005m} \quad \textbf{/(1 mark)}$$

Q19. a) (i) -The intensity of the incident radiation **(1 mark)**

-The type of the metal surface
-The frequency of the incident radiation

(ii) -An electron moves around the nucleus in a circular motion **(1mark)**
-An electron can jump from one orbit to another higher energy on the absorption of energy and one orbit to another lower energy orbit with the emission of energy.
- An electron's angular momentum in the orbit is quantized.

b) (i) Photoelectric effect **(1 mark),** Compton effect **(1 mark)**
(ii) Reflection of light **(1 mark),** refraction of light **(1 mark),** interference of light [any two].

c) (i) The frequency $f = \frac{c}{\lambda}$ **(1 mark)**

$$f = \frac{3x10^{8}}{350x10^{-9}} Hz = 8.57x10^{14} Hz \quad \textbf{(1 mark)}$$

(ii) The work function is given by $hf = \phi + KE$ **(1 mark)**

ϕ = 6.626x10^{-34}x 8.57x10^{14} J-1.20 x1.6x10^{-19} J

=5.657x10^{-19} J-1.92 x10^{-19} J=3.737x10^{-19} J

$$= \frac{3.737x10^{-19}}{1.6x10^{-19}} = 2.34eV \quad \textbf{(1 mark)}$$

Q20. a) (i) The thermionic emission is the process by which an electron is liberated from the surface of metal heated. **(1 mark)**

(ii) Cathode rays are steams of electrons moving at high speed in a tube highly evacuated. **(1 mark)**

b) Properties of cathode rays: [any two properties]

- They travel from the cathode in a straight line **(0.5 mark)**
- They cause certain substances to fluoresce **(0.5 mark)**
- They can be deflected by electric field
- They can be deflected by magnetic field
- They can produce x-rays when they strike heavy metals
- They are negatively charged
- They possess kinetic energy which is converted into heat and light on hitting the fluorescent screen

(c) (i) The direction of the electric force on the electron is downward in Figure, opposite the direction of the electric field lines

$$a_y = \frac{eE}{m_e} \quad \textbf{(1 mark)}$$

$$Implies\ a_y = \frac{(1.60 \times 10^{-19}C)(200N/C)}{9.11 \times 10^{-31}kg} = 3.51 \times 10^{13} m/s^2 \ \textbf{(1 mark)}$$

(ii) For the time at which the electron arrives at the right edges of the plates

Using kinematics equation: $x = v_x t + x_0$ **(0. 5 mark)**

$$t = \frac{x_{i-0}}{v_x} = \frac{0.100m - 0m}{3.00\times10^6 m/s} = \mathbf{3.33 \times 10^{-8} s} \quad \textbf{(0.5 mark)}$$

(iii) Because the electric force is constant, the motion of the particle in the vertical direction can be analysed by modelling it as a particle under constant acceleration.

$y_1 = \frac{1}{2}a_y t^2 + u_y t + y_i$ **(1 mark)**

$y_1 = \frac{1}{2}(3.51 \times 10^{13} m/s^2)(3.33 \times 10^{-8} s)^2 + 0 + 0 = 1.95 \times 10^{-2} m$ **(1 mark)**

(**iv)** Consider the electron's path outside the plate is a straight line:

$$y_2 = x_2 tan\theta = x_2\left(\frac{v_y}{v_x}\right) = x_2\left(\frac{a_y t}{v_x}\right) = \frac{eEx_1x_2}{m_e v_x^2}$$

So, $y_2 = \frac{eEx_1x_2}{m_e v_x^2} = \frac{(1.60\times10^{-19}C)(200N/C)(0.100m)(0.200m)}{(9.11\times10^{-31}kg)(3.00\times10^6 m/s)^2} = 7.81 \times 10^{-2} m$

The total vertical deflection/path of the electron on the screen is given by both deflections:

$y = y_1 + y_2 = \frac{eEx_1}{m_e v_x^2}(x_2 + \frac{x_1}{2})$ **(1 mark)**

$y = (1.95 + 7.81) \times 10^{-2} m = \mathbf{9.76 \times 10^{-2} m}$ **(1 mark)**

END!!