S6 PHYSICS EXAMINATION MARKING GUIDE
THEORY - 2024

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SECTION A: / 55 marks

(1) a) (i) Gravitational potential at a point is defined as the work to remove a unit mass (1kg) from infinity to the given point. ✓ 1

(ii) $V = -\frac{GM}{r}$ ✓ 1

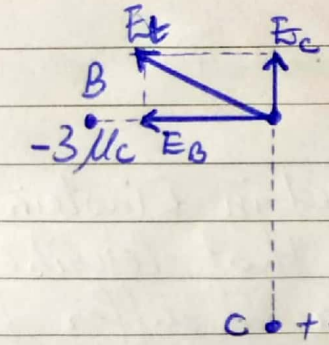
where V: is the gravitational potential.
M: Mass.
r: The distance of the unit mass from the fixed mass.
G: Is the universal gravitational constant.

b) "The square of the total time period T of the orbit is directly proportional to the cube of the average distance of the planet to the Sun." ✓ 1

3 marks

(2) a) The resultant electric field at a point in space due to many charges is the vector sum of electric fields due to the individual electric charges. ✓ 1

b)



$E_B = \frac{kQ_B}{r_1^2} = \frac{9\times10^{9}\times3\times10^{-6}}{(0.12\times10^{-2})^2}$ N/C

$= 1.875\times10^{6}$ N/C ✓4

and $E_C = \frac{kQ_C}{r_2^2} = \frac{9\times10^{9}\times3\times10^{-6}}{(0.2\times10^{-2})^2}$

$= 0.675\times10^{6}$ N/C ✓4

$E_t = \sqrt{E_B^2 + E_C^2} = \sqrt{(1.875\times10^6)^2 + (0.675\times10^6)^2}$ ✓ 0.5

$= 1.99\times10^6 \text{ N/C}$ ✓ 0.5

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The direction of the net electric field at point A is given by the angle $\theta = \tan^{-1}\left(\frac{E_C}{E_B}\right)°$

$\therefore \theta = \tan^{-1}\left(\frac{0.675}{1.875}\right)° \simeq 19.8°$ ✓ to the horizontal above the -ve X-axis. 1

(3) a) Analog systems represent information using continuously variable physical quantities ✓ such as voltage or current, while digital systems represent information using discrete values ✓ typically encoded as binary numbers. 1 1

b) - Analog systems offer advantages such as simplicity, real time process and a potentially infinity range of values. However, they are susceptible to noise ✓ and degradation over time. 0.5 0.5

- Digital systems provide advantages like accuracy, robustness against noise ✓ and ease of process and storage. However, they may suffer from quantization errors ✓ and require more complex processing. 0.5 0.5

(4) a) iii ✓ 1
b) iv ✓ 1
c) iii ✓ 1

3 marks

(5) a) Time dilation is a concept used in Einstein is theory of special relativity that describes ✓ how time intervals appear to differ for 1

Observers who are moving relative to each other at speeds close to the speed of light.

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b) $t' = \frac{t}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{10}{\sqrt{1-\left(\frac{0.8c}{c}\right)^2}}$ years $= 16.67$ years. 1+1

So, for every 10 years that pass on the Earth, approximately 16.67 years pass on the spaceship. 3marks

(6) a) (i) The path difference for bright fringes;

$\Delta r = n\lambda$ where $n = 0, 1, 2, 3, 4,$ etc 0.5+0.5

or $\Delta r = n'\frac{\lambda}{2}$ with $n' = 0, 2, 4, 6, 8,$ etc

(ii) The path difference for dark fringes;

$\Delta r = m\frac{\lambda}{2}$ where $m = 1, 3, 5, 7,$ etc. 0.5+0.5

or $\Delta r = (2m'-1)\frac{\lambda}{2}$ with $m = 1, 2, 3, 4,$ etc.

b) $x_8 = 5\text{mm} = 5\times10^{-3}\text{m}$, $\lambda = 6.2\times10^{-7}\text{m}$, $\Delta = 80\times10^{-2}\text{m}$.
$d = ?$

$\frac{n\lambda}{d} = \frac{x_n}{\Delta} \Rightarrow d = \frac{n\lambda\Delta}{x_n} = \frac{8\times6.2\times10^{-7}\times80\times10^{-2}}{5\times10^{-3}}\text{m}$ 1

$\Rightarrow d = 7.936\times10^{-4}\text{m}$ 1

4marks

(7) a) Factors influencing the luminosity of a star:
- Its size / surface area. 1
- Its temperature 1

b) The Sun's luminosity $L_s = 4\pi\sigma R_s^2 T_s^4$

The star luminosity, $L = 4\pi\sigma R^2 T^4$ 1

$L = 4\pi\sigma (3R_s)^2 (2\bar{T}_s)^4 \Rightarrow L = 4\pi\sigma \times 3^2 R_s^2 \times 2^4 \bar{T}_s^4$

$\Rightarrow L = 3^2 \times 2^4 \times (4\pi\sigma R_s^2 \bar{T}_s^4) \Rightarrow L = 144 L_s$ ✓ 1

4marks

(8) a) The following diagram indicates a radio receiver. ✓ (any three points are marked). 1

b) - The receiving antenna: ✓
converts radio waves into electrical signals 1

- RF tuner and amplifier:
Is used to select the desired radio signals, and to amplify it. ✓ 1

- Demodulator: Is used to separate the original signals from the radio signals/carrier signals ✓ 1

- AF amplifier: Is an electronic device used to amplify the audio frequency signals from the demodulator.

4marks

(9) a) Baryons ✓, mesons ✓ 0.5+0.5
b) Quarks ✓, Leptons ✓ 0.5+0.5
c) Protons ✓, neutrons ✓ 0.5+0.5
d) antibaryons ✓ 1

4marks

(10) a) uud: Is a baryon ✓ or a proton. 1
with u: is an up-quark ✓ and d- is a down quark ✓ 0.5+0.5

b) $b\bar{u}$: Is a meson ✓ or π^- meson. 1
b- is a botton ✓ quark and $\bar{u}$ is an anti-up ✓ 0.5+0.5

4marks

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(11) a) (i) causes of earthquake: (any one)
- Volcanic activities/eruption ✓
- Mining activities;
- Nuclear weapon testing
- etc

(ii) Causes of Tsunami: (any one)
- landslide on under sea floor ✓ 1
- Earthquake;
- Large volcanic eruption;
- etc.

(iii) One way of preventing landslide: (any one)
- Afforestation/reafforestation ✓ 1
- construction of retaining walls;
- Prevent soil erosion.

(b) (i) One effect of cyclone: (any one)
- Destruction of buildings and other infrastructure ✓ 1
- loss of lives
- landslides;
- displacement of people;
- Vegetation degradation; etc

4 marks

(12) a) (i) Black body radiations: Are radiations whose wavelengths depend on the temperature of the body. ✓ 1

(ii) Albedo: Is the ratio of the power of the reflected radiation by the surface of the planet to the total power of the incident radiation. ✓ 1

b) (i). Because bodies emit radiations at all wavelengths since no object can have temperature below absolute zero. So, all bodies emit ✓ some radiations 1

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b)(ii) From $\lambda_{max} T = b \Rightarrow \lambda_{max} = \frac{b}{T}$ ✓

$\Rightarrow \lambda_{max} = \frac{2.9 \times 10^{-3} mk}{2000 K} = 1.45 \times 10^{-6} m \simeq 1450 nm$ ✓

(iii) As the power of the blackbody increases, the peak wavelength decreases. ✓

0.5 0.5 1 (5marks)

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(13) a) Binding energy is the energy released when a nucleus is formed from its constituents or energy required when a nucleus spits into its constituents. ✓ 1

b) $E = \Delta m c^2$.

with $\Delta m = (m_p Z + N m_N) - M$

$\therefore \Delta m = [(1.007276 \times 6 + 1.008665 \times 8) - 14.003240]u$

$\Delta m = (6.043656 + 8.06932) - 14.003240\ u.$

$= (14.112976 - 14.003240)u = 0.109736\ u.$

$= 0.109736 \times 1.66 \times 10^{-17} kg = 1.821176 \times 10^{-18} kg$ ✓ 1

$E = 1.821176 \times 10^{-18} \times (3 \times 10^8)^2 J = 1.6394584 \times 10^{-1} J$

$E = \frac{1.6394584 \times 10^{-1}}{1.6 \times 10^{-19}} eV = 1.024699 \times 10^{18} eV = 10^{12} MeV$ ✓ 1

c) Half life is 5 days. ✓ 1 (4marks)

(14) a) Is an electromagnetic radiation. ✓

- Has no mass
- Has no charge
- Can not be deflected by both magnetic field and electric field.

1 (any one)

b) For y: $210 = y + 0 \Rightarrow y = 0$ ✓

For x: $84 = x + (-1) \Rightarrow x = 85$. ✓

1 1 (3marks)

(15) a) $C = \sin^{-1}\left(\frac{1}{n}\right)^\circ = \sin^{-1}\left(\frac{1}{2.42}\right)^\circ = 24.407^\circ$ ✓ 1

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b) When the angle of incidence is greater than the critical angle, ie $i > 24.407^\circ$, then total internal reflection takes. ✓ 1

2 marks

SECTION B:

(16) a) Uniform circular motion is a type of motion where a body moves along a circular path with a constant speed. ✓ 2

b) $v = 52.5\,km/h = 14.583\,m/s$. $D = 60cm \Rightarrow r = \frac{D}{2} = 30cm$.

$$\omega = \frac{v}{r} \checkmark = \frac{14.583}{30\times10^{-2}} \checkmark rad/s = 48.61\,rad/s. \checkmark \quad 1+1+1$$

c) Applications of projectile motion:
- Playing football, ✓ basket ball, etc 1
- Rockets and bomb launchers. ✓ 1
- etc.

d)(i) $H_{max} = \frac{v_0^2 \sin^2\theta}{2g} \checkmark = \frac{400^2 \times \sin^2 45^\circ}{2\times9.81}\,m = 4077.41\,m$ ✓ 1+1

(ii) $X = \frac{v_0\cos\theta}{g}\left(v_0\sin\theta + \sqrt{v_0^2\sin^2\theta + 2gh}\right)$ ✓ 1

$$\therefore X = \frac{400\times\cos45}{9.81}\left(400\sin45^\circ + \sqrt{400^2\sin^2 45^\circ + (2\times9.81\times100)}\right)m$$

$= 16409.28\,m$. ✓ 1

(iii) $x = v_0\cos\theta \cdot t$ ✓ $\Rightarrow t = \frac{x}{v_0\cos\theta} = \frac{16409.28}{400\cos45^\circ}\,sec$ 1

$\Rightarrow t = 58\,sec$. ✓ 1.

(iv) $v = \sqrt{v_0^2 - 2v_0\sin\theta \cdot g \cdot t + g^2t^2}$ ✓ 1.

$$V = \sqrt{400^2 - (2\times 400 \times \sin 45° \times 9.81 \times 58) + (9.81\times 58)^2} \ m/s$$

$= 402 \ m/s.$ ✓

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15 marks

(17) a) - Stationary waves do not transfer energy while progressive waves transfer energy from point to another. ✓ 1

- For stationary waves, particles at nodes are permanently at rest whereas for progressive waves no particles are permantly at rest ✓ 1

b) - The wave number is the number of wavelengths per unit length ✓ 1

- Phase difference: Is the angular difference between two points on a wave or between two waves. ✓ 1

c) The interfering waves must be monochromatic ✓ and coherent. ✓ 1+1

d) (i) $y = a\sin\left(100\pi t + \frac{10\pi}{9}x\right)$ ✓ 1

(ii) $y = y_1 + y_2$ ✓ 1

ie $y = a\sin\left(100\pi t + \frac{10\pi}{9}x\right) + a\sin\left(100\pi t - \frac{10\pi}{9}x\right)$ ✓ 1

$y = 2a\cdot\cos\frac{10\pi}{9}x \sin 100\pi t$ ✓ 1

The amplitude; $A = 2a\cos\frac{10\pi}{9}x$ ✓ 1

(iii) $100\pi = 2\pi f \Rightarrow f = 50 Hz$ ✓ 1

$V = \lambda f$ with $K = \frac{10\pi}{9} \Rightarrow \frac{2\pi}{\lambda} = \frac{10\pi}{9}$

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$\Rightarrow \lambda = 1.8\,mm \Rightarrow \lambda = 0.0018\,m.$

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$V = (50 \times 0.0018)\,m/s = 0.09\,m/s.$ ✓ 1

(e) $\Delta\theta = 360° \frac{t}{T}$ ✓ $= 360° \times \frac{17ms}{60ms} = 102°.$ ✓ 1+1

15 marks

(18) (a) $V = 1500m/s$; $t = 0.55sec$; $d = ?$

$2d = V \times t$ ✓ $\Rightarrow d = \frac{1500 \times 55}{2} = 412.5\,m.$ ✓ 1+1

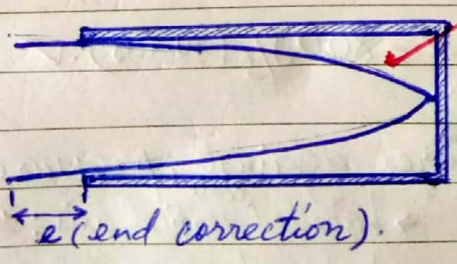
(b) (i) Doppler effect is the apparent change in frequency of sound ✓ when there is relative ✓ motion between the source and the observer. $0^5 + 0^5$

(ii) Two real life applications of Doppler effect are:
- Radar system ✓
- Sonar ✓
- To measure the speed of an automobile; etc.

1 (any two)
1

(c) Open pipe (tube) is preferred because:
- Open pipe produces notes of better quality than closed pipe. ✓ 1
- Open pipe produces both odd and even harmonics (many harmonics) while closed pipe produces only odd harmonics (few harmonics). ✓ 1

(d) (i)



1

(ii) $l = 0.68\,m$; $e = 0.002m$; $V = 340\,m/s$

$f_0 = \frac{V}{4(l+e)}$ ✓ $\Rightarrow f_0 = \frac{340}{4(0.68+0.002)}\,Hz = 124.63Hz$ ✓ 1+1

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(e) $f_s = 500\,Hz$;
$V_A = 0\,m/s$.
$V_B = 35\,m/s$.
$V_o = 20\,m/s$.
$C = 340\,m/s$.

(i) $f_A = f_s\left(\frac{C - V_o}{C}\right)$ ✓ $= 500 \times \left(\frac{340-20}{340}\right) Hz = 470.588\,Hz$ ✓ 1+1

(ii) $f_B = f_s\left(\frac{C+V_o}{C+V_B}\right)$ ✓ $= 500 \times \left(\frac{340+20}{340+35}\right) Hz = 480\,Hz$ ✓ 1+1

(iii) $\Delta f = f_B - f_A = 480\,Hz - 470.588\,Hz = 9.412\,Hz$ ✓ 1

15 marks

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(19) (a) $P_1 = P_2 = 2\times10^5\,Pa$; $V_1 = 0.02\,m^3$; $V_2 = 0.03\,m^3$, $T_1 = 27°C$

(i) $W = P\Delta V$ ✓ $= 2\times10^5 \times (0.03 - 0.02)\,J = 2000\,J$ ✓ 1+1

(ii) $27°C = (27 + 273)K = 300\,K$ ✓ 1+1

(iii) $T_2 = ?$

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ ✓ $\Rightarrow T_2 = \frac{V_2}{V_1} T_1 = \frac{0.03}{0.02} \times 300\,K = 450\,K$ ✓ 1+1

(b) $Q_{in} = 2000\,J$; $Q_c = 1500\,J$

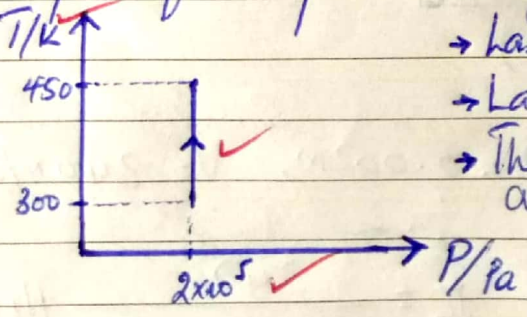
(i) $\eta = \left(\frac{Q_{in} - Q_c}{Q_{in}}\right) \times 100\% = \left(\frac{2000J - 1500J}{2000J}\right) \times 100\%$ 1

$= 25\%$ ✓ 1

(ii) $W_{out} = Q_{in} - Q_c = 2000\,J - 1500\,J = 500\,J$. ✓ 1+1

(iii) $P = \frac{W_{out}}{t} = \frac{4\times500\,J}{2.5\,sec} = 800\,J/s\,(watts)$. ✓ 1+1

(c) A graph of temperature against pressure:



→ Labelled scaled vertical axis : 1mark 1
→ Labelled horizontal axis : 1mark
→ The vertical line with an arrow : 1mark 1
1

15 marks

(20) a) X-rays are electromagnetic radiowaves / radiations ✓ produced when cathode rays ✓ (fast moving electrons) hit the metal surface.

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b) Tungsten has high melting point ✓ and high atomic weight. ✓ 1 1

c) The anode of an X-ray tube is positive ✓ 1

d) Applications of X-rays: (any two).
- X-ray image technique uses X-rays. ✓ 1
- X-rays are used for killing cancerous cells
- X-ray diffraction provides one of the most important tools for examining the three-dimentional (3D) structure of biological macromolecules and cells.
- X-ray scaning is used at airports, banks, ✓ supermarkets, etc to examine luggage for weapons or bombs, etc 1

e) Dangers of X-rays: (any two).
- X-rays cause demage to living fissues. ✓ 1
- Can speed up the age. ✓ 1
- Can reduce immunity to disease,
- etc

f) $V = 1\times10^{5}\,V$; $e = 1.6\times10^{-19}\,C$; $h = 6.63\times10^{-34}\,Js$.
$f_{max} = ?$

$eV = h f_{max}$ ✓ $\Rightarrow f_{max} = \frac{eV}{h} = \frac{1.6\times10^{-19}\times1\times10^{5}}{6.63\times10^{-34}}\,Hz$ ✓ 1+1

$\Rightarrow f_{max} = 2.41\times10^{19}\,Hz$ ✓ 1

g) $\lambda = 0.06\,nm = 0.06\times10^{-9}\,m$; $\theta = 11.7°$, $m = 1$
$d = ?$

$m\lambda = 2d\sin\theta$ ✓ (From Bragg's law). 1

$\Rightarrow 0.06\times10^{-9} = 2d\sin 11.7°$ ✓ $\Rightarrow d = 1.479\times10^{-10}\,m$ ✓ 1+1

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END