62

RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
First Year - Semester II Examination – September/October 2020

PHY 1104 – MODERN PHYSICS

Time: Two (01) hours

- **Answer all questions.**
- A non-programmable calculator is permitted.

Values of constants

speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \text{ms}^{-1}$
electron charge	$e = 1.60 \times 10^{-19}\ C$
the Plank constant	$h = 6.63 \times 10^{-34}\ \text{Js}$
mass of electron	$\text{m}_e = 9.11 \times 10^{-31}\ \text{kg}$
mass of proton	$\text{m}_p = 1.67 \times 10^{-27}\ \text{kg}$
acceleration of free fall on the Earth's surface	$\text{g} = 9.81\ \text{ms}^{-1}$
electron volt	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$

---

1. Consider a particle of mass m moving at a speed of $0.10c$. What is the kinetic energy according to;

   a) the Newtonian formula? (03 marks)

   b) the relativistic formula? (04 marks)

   c) the percent deviation between these two results? (03 marks)

Continued...

2. A radioactive atom in a beam produced by an accelerator has a speed of $0.80c$ relative to the laboratory. The atom decays and ejects an electron of speed $0.50c$ relative to itself. What is the speed of the electron relative to the laboratory if ejected in;

   a) the forward direction? (05 marks)

   b) the backward direction? (05 marks)

3. a) When a highly accelerated electron beam is 'boiled out' from the cathode filament and strikes the target anode of an X-ray tube, **two types** of X- radiation are produced.
   State and describe the two types of X-radiation. (06 marks)

   b) The total power of X-rays generated by an X-ray tube is 21W.
   The efficiency of conversion of kinetic energy of the electrons into X-ray photon energy is 0.15%.

      i. Calculate the power of the electron beam. (02 marks)

      ii. Calculate the velocity of the electrons if the rate of arrival of electrons is $9.0 \times 10^{17} s^{-1}$. Relativistic effects may be ignored. (02 marks)

4. A satellite, initially at rest in space, explodes into two pieces. One piece has a mass of 150kg and moves away from the explosion with a speed of $0.76c$. The other piece moves away in the opposite direction with a speed of $0.88c$. Find the mass of the second piece of the satellite. (10 marks)

Continued...

Formula Sheet

$$\Delta t = \gamma \Delta t_p \quad \text{and} \quad L = \frac{L_p}{\gamma} \quad \text{where,} \quad \gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$x' = \gamma(x - vt) \qquad y' = y \qquad z' = z \qquad t' = \gamma\left(t - \frac{v}{c^2}x\right)$$

$$x = \gamma(x' - vt') \qquad y = y' \qquad z = z' \qquad t = \gamma\left(t' - \frac{v}{c^2}x'\right)$$

$$\left.\begin{aligned} \Delta x' &= \gamma(\Delta x - v\,\Delta t) \\ \Delta t' &= \gamma\left(\Delta t - \frac{v}{c^2}\Delta x\right) \end{aligned}\right\} S \to S' \qquad \left.\begin{aligned} \Delta x &= \gamma(\Delta x' + v\Delta t') \\ \Delta t &= \gamma\left(\Delta t' + \frac{v}{c^2}\Delta x'\right) \end{aligned}\right\} S' \to S$$

$$u'_x = \frac{u_x - v}{1 - \frac{v}{c^2}u_x} \qquad u'_y = \frac{u_y}{\gamma\left(1 - \frac{v}{c^2}u_x\right)} \qquad u'_z = \frac{u_z}{\gamma\left(1 - \frac{v}{c^2}u_x\right)}$$

$$\vec{\mathbf{p}} \equiv \frac{m\vec{\mathbf{u}}}{\sqrt{1-\frac{u^2}{c^2}}} = \gamma m\vec{\mathbf{u}} \qquad \vec{F} \equiv \frac{d\vec{\mathbf{p}}}{dt}$$

$$K = (\gamma - 1)mc^2 \qquad E_R = mc^2 \qquad E = K + mc^2 \qquad E^2 = p^2c^2 + (mc^2)^2$$

$$W = qV \qquad P = \frac{W}{t} \qquad KE = \frac{1}{2}mv^2$$

---END---