BUDINSE MEMORIAL SCHOOL

END OF TERM ONE PHYSICS THEORY EXAMINATION

CLASS: SENIOR FIVE (S5) | **PAPER:** P510/1
TIME: 2 HOURS 40 MINUTES

SECTION A (COMPULSORY)

ITEM 1

The display screens of digital devices use Light Emitting Diodes (LEDs) which emit high amounts of blue light. A Senior Five ICT student is worried that their eyes are at risk due to continuous use of computers. To investigate the nature of this light, students set up an experiment to determine the stopping potential of a photo-emissive surface.

Support Material:

- Wavelength of blue light (λ): $450\ \text{nm}$
- Planck's constant (h): $6.63 \times 10^{-34}\ \text{Js}$
- Speed of light (c): $3.0 \times 10^{8}\ \text{m/s}$
- Damage threshold for the human eye: $3.1\ \text{eV}$
- Charge of an electron (e): $1.6 \times 10^{-19}\ \text{C}$

Tasks:

(a) State the laws of photoelectric emission.

(b) Calculate the energy of a blue light photon in **eV**. Use this to advise the student on whether the light exceeds the eye's damage threshold.

(c) Describe, with the aid of a labeled circuit diagram, an experiment to determine the stopping potential of a metal surface.

(d) Explain how a graph of stopping potential (V_s) against frequency (f) can be used to determine Planck's constant.

(e) Suggest three protective strategies to safeguard the eyes from high-energy display radiations.

SECTION B

ITEM 2

(a) Dan wishes to travel a distance of $0.6\ \text{km}$ by bus. The bus travels with uniform acceleration from rest to a speed of $60\ \text{ms}^{-1}$ in $2\ \text{hours}$. When he reaches his destination, the driver brakes uniformly to a halt in a distance of $42\ \text{m}$.

Tasks:

(i) Derive the equations of motion used to solve Dan's queries from first principles.

(ii) Determine the acceleration and the distance covered in the first part of the journey.

(iii) Calculate the deceleration and the time taken to stop the car.

(b) In a football match, a goalkeeper is seen drawing his hands backwards while catching a fast-moving ball to avoid injury.

Tasks:
(i) State Newton's Three Laws of Motion.
(ii) Using Newton's Second Law of Motion, explain why the goalkeeper draws his hands backwards.
(iii) Describe the relationship between force, mass, and the rate of change of momentum.

SECTION C

ITEM 3

(a) You are working as a design engineer at a manufacturing company. Your team is developing a new high-precision weighing scale for laboratory use.

Tasks:
(i) Identify the fundamental and derived physical quantities required in the calibration of the weighing scale.
(ii) Use dimensional analysis to check whether the following equations are dimensionally consistent:

- The force acting on the mass: $F = mg$
- The oscillation period of the scale's pan: $T = 2\pi\sqrt{\frac{l}{g}}$

  (iii) Explain why dimensional analysis is crucial in verifying equations before building a prototype.

(b) A prototype component of mass $8\ \text{kg}$ is subjected to four coplanar forces acting in different directions as described below:

- **Force F_1:** $40\ \text{N}$ acting due East.
- **Force F_2:** $30\ \text{N}$ acting at an angle of 60° North of East.
- **Force F_3:** $20\ \text{N}$ acting due North.
- **Force F_4:** $25\ \text{N}$ acting at an angle of 45° South of West.

Tasks:
(i) Resolve each force into its horizontal (x) and vertical (y) components.
(ii) Calculate the magnitude and direction of the resultant force acting on the component.
(iii) Determine the magnitude of the acceleration produced by this resultant force.
(iv) Discuss how dimensional errors in mass or force calculations could lead to design failure.

SECTION D

ITEM 4

(a) Define the following terms as used in mechanics:
(i) Projectile motion.
(ii) Trajectory.

(b) Derive the equation of a trajectory for a projectile launched with an initial velocity u at an angle θ to the horizontal.

(c) **Case Study I:**
As a coach analyzing a sprinter's 100-meter dash, you note the sprinter starts from rest and accelerates at $2.5\ \text{ms}^{-2}$ for the first $4\ \text{seconds}$, then continues at a constant velocity until the finish line.
(i) Calculate the maximum velocity the sprinter reaches and the total time taken to complete the race.
(ii) Explain how reaction time and running technique affect overall performance.

(d) **Case Study II:**
A ship in distress fires a flare vertically upward with an initial speed of $50\ \text{ms}^{-1}$. Take $g = 9.81\ \text{ms}^{-2}$.
(i) Calculate the maximum height reached and the total time before the flare returns to the water.
(ii) Discuss the effects of wind and air resistance on the flare's trajectory.
(iii) Suggest alternative emergency signals that could be used in poor weather conditions.

> **"Your present circumstances don't determine where you can go; they merely determine where you start."**
> — *Deron Quotes*