INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
  - drawing instruments;
  - non-programmable scientific calculator.

This paper consists of THREE sections; A, B and C.
Answer ONE question from section A, ONE question from section B and THREE questions from section C in the answer booklet provided.
Maximum marks for each part of a question are as indicated.
Candidates should answer the questions in English.

Take $U^0 = 4\pi \times 10^{-1} \text{H/m}$ and $\varepsilon^0 = 8.85 \times 10^{-12} \text{F/m}$

This paper consists of 8 printed pages.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.
SECTION A: PHYSICAL SCIENCE

Answer ONE question from this section.

1. (a) State four properties of acids. (4 marks)

(b) (i) Outline two advantages of nuclear fuel over fossil fuel.

(ii) Explain the function of the following components of a nuclear reactor:

(I) graphite core;

(II) control rods. (6 marks)

(c) (i) Name two homologous series for hydrocarbons.

(ii) Differentiate between 'covalent' and 'dative' bonds. (6 marks)

(d) Explain two factors which determine preferential discharge of ions during electrolysis. (4 marks)

2. (a) State two uses of microwaves. (4 marks)

(ii) Determine the energy possessed by microwave at a wavelength of 20 cm. Take plank's constant as $6.63 \times 10^{-34}$ Js and speed of light as $3.0 \times 10^8$ m/s. (6 marks)

(b) Define the following terms as used in simple harmonic motion:

(i) displacement;

(ii) amplitude. (2 marks)

(c) Derive an expression for velocity, $V$ of a simple harmonic motion in terms of displacement, $y$, amplitude, $A$ and angular speed, $\omega$. (5 marks)

(d) Small pieces of dry melting ice of total mass 220 g at 0°C were added to water of mass 300 g at 95°C contained in well lagged copper calorimeter of heat capacity 300 J/k. When all ice has melted and the content stirred, a steady temperature of 30°C was obtained. The specific heat capacity of water is 4200 J/kg.k. Determine the specific latent heat of fusion of the ice. (7 marks)
SECTION B: MECHANICAL SCIENCE

Answer ONE question from this section.

3. (a) (i) Define the following terms as used in mechanics:

(I) kinetic energy;

(II) impulse.

(ii) An object of mass 12 kg falls freely from a height of 8 m above the ground level. Determine the impulse experienced by the object on hitting the ground. (force of gravity is 9.8 N/kg)  

(b) State three applications of impulse in mechanics.  

(c) Figure 1 shows 100 kg object supported by a hinged rigid beam. Determine the magnitude of force in the beam.

(d) (i) State the principle of transmission of fluid pressure;

(ii) With aid of a diagram, describe turbulent flow of liquid in circular pipe.
4. (a) Outline **three** differences in operation of centrifugal type over inertia type of governors. (6 marks)

(b) Explain how drive belt coupling can be used to change speed of driven shaft. (2 marks)

(c) Figure 2 shows an angular position-time graph for a particle moving in a circular path:
   (i) Describe the velocity of motion;
   (ii) Determine the period of motion. (6 marks)

![Graph](image)

**Fig. 2**

(d) An electric power transmission cable is made of aluminium alloy of cross-section area 120 mm² and length 95 m. The tensile stress and Young modulus of the cable is 290 MN/m² and 70 GN/m² respectively. Determine the:
   (i) greatest tensile force it can withstand;
   (ii) maximum extension on the cable under stress condition. (6 marks)
Answer **THREE questions from this section.**

5. (a) Describe the effects of the following forces produced in electrical indicating instruments:
   (i) deflecting force;  
   (ii) damping force;  
   (iii) controlling force.  
   (6 marks)

(b) Outline **two** differences between a moving-coil and a moving-iron instrument.  
   (4 marks)

(c) **Figure 3,** shows a signal waveform on a cathode ray oscilloscope (CRO) display. The time-base setting is 2.1 ms/cm while the sensitivity is 2.5 V/cm. Determine the:
   (i) mean value of the signal;  
   (ii) supply frequency.  
   (6 marks)

(d) Differentiate between 'constant-voltage' and 'constant-current' methods of charging a battery.  
   (4 marks)
6. (a) State Kirchoff's laws. (4 marks)

(b) Figure 4 shows electric circuit. Using Kirchoff's laws, determine the current flowing through the 5 Ω resistor. (7 marks)

(c) An aluminium overhead power cable has cross-section area of 1.2 x 10^{-4} m^2. The resistivity of the aluminium is 2.6 x 10^{-8} Ω m. Determine the resistance of a 3000 m length of the cable. (3 marks)

(d) (i) Draw a phasor diagram for an RL circuit;

(ii) Sketch the current and voltage waveforms of d(i) on the same axes. (6 marks)

7. (a) Define dielectric strength of a material. (2 marks)

(b) A two-plate mica capacitor has a dielectric strength of 50 x 10^9 V/m and a plate area of 940 cm^2. The dielectric is 0.025 mm thick and has a relative permittivity of 5. Determine the:

(i) rated terminal voltage;
(ii) capacitance;
(iii) maximum energy it can store. (6 marks)

(c) Figure 5 shows an electromagnetic circuit:

(i) Draw the circuit and indicate direction of current flow in the solenoid;
(ii) Identify the poles of the magnet;
(iii) Show the lines of magnetic flux. (8 marks)
(d) A conductor 6 cm long cuts a magnetic field of flux density 0.85 T at a speed of 62 m/s. Determine the e.m.f induced:

(i) at maximum flux linkage;
(ii) when conductor cuts flux at an angle of 60°.  

(4 marks)

8. (a) State two:

(i) advantages of auto-transformers;
(ii) applications of a(i).  

(4 marks)

(b) The instantaneous value of a.c voltage supply is given by

\[ V = 110 \sin (100 \pi t + 0.2 \pi) \text{ volts} \]

Determine the:

(i) amplitude;
(ii) r.m.s value of the voltage;
(iii) phase angle;
(iv) supply frequency.  

(6 marks)

(c) Figure 6 shows an equivalent circuit of a transformer:

(i) Sketch a simplified equivalent circuit;
(ii) For the circuit in c(i), determine the:

(I) equivalent impedance;
(II) phase angle.  

(10 marks)