**The Open University of Sri Lanka**

**Advanced Certificates in Science Programme- 2024/2025**

**PHF2526- Physics 04**

**Final Examination**

**Duration: Three (03) hours** **Index Number:.....**

**08nd March 2025** **Time: 09.30 a.m. -12.30 p.m.**

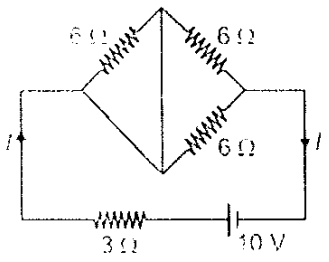
- Question Paper is consisting of Part I and Part II
- Answer **25 MCQ's** in **Part I**
- In each of the questions **1-25**, pick one of the alternatives from (1), (2), (3), (4), (5) which is **correct** or **most appropriate**, and **underline your response**
- **Part II** is consisting of six (06) essay questions.
- At the end of the examination, you should submit the question paper

## Part I

- Answer all the **25 MCQ's**

1. Kirchhoff's second law, i. e. $\sum E = \sum IR$ in a closed electrical circuit, deals with the conservation of
   (i) Charge (ii) Energy (iii) charge and energy
   (iv) Momentum (v) None of above

2. The current I through the circuit is

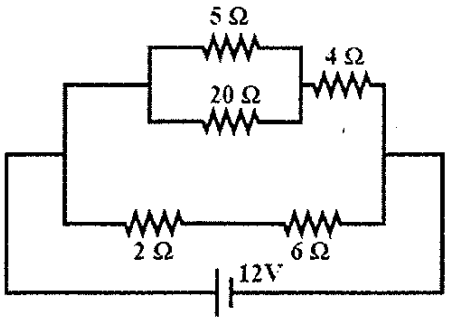



(i) 5 A (ii) I A (iii) 5/3 A (iv) 0 A (v) 6 A

3. Which of the following is a characteristic of an ideal ammeter?

   (i) Infinite resistance (ii) Zero resistance
   (iii) High resistance (iv) Variable resistance
   (v) Negative resistance

4. A circuit containing five resistors is connected to a battery with a 12 V emf as shown in figure. The potential difference across 4 Ω resistor is




(1) 1V (2) 3V (3) 6V (4) 9V (5) 12V

5. A potentiometer is used to measure the electro motive force (EMF) of a cell. If the length of the potentiometer wire is 100 cm and the balancing length is 40 cm, what is the EMF of the cell if the standard cell EMF is 2 V?

   (i) 0.4 V (ii) 0.8 V (iii) 1.2 V (iv) 1.6 V (v) 2 V

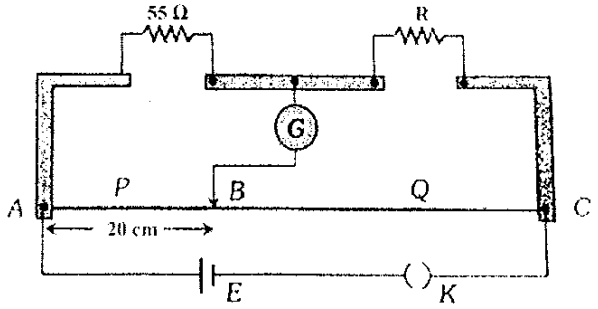
6. If a voltmeter with a resistance of 10 kΩ is connected in parallel to a resistor of 1 kΩ, what is the voltmeter reading if the supply voltage is 10 V?

   (i) 0.9 V (ii) 1 V (iii) 5 V (iv) 9.1 V (v) 10 V

7. Calculate the power dissipated in a resistor of 5 Ω if the current flowing through it is 2 A

   (i) 2 W (ii) 4 W (iii) 8 W (iv) 10 W (v) 20 W

8. The figure shows a balanced meter bridge setup with the null deflection in the galvonometer. The value of the unknown resistance R is




(i) 110 Ω (ii) 55 Ω (iii) 220 Ω (iv) 440 Ω (v) 11 Ω

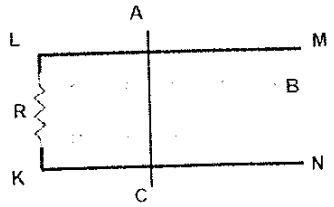
9. A voltmeter of range 1 V has a resistance 1000 Ω. To extend the range to 10 V, the additional series resistance required is,
(i) 9000 Ω (ii) 10,000 Ω (iii) 5000 Ω (iv) 1000/9 Ω (v) 2000 Ω

10. If a device consumes 1000 W of power and runs for 5 hours, how much energy does it consume in kWh?
(i) 1 kWh (ii) 2 kWh (iii) 3 kWh (iv) 4 kWh (v) 5 kWh

11. A coil of an area 2 $m^2$ is placed in a magnetic field which changes from 4 Wb/ $m^2$ in 2 Seconds. Find the induced e.m.f in the coil
(i) 4 V (ii) 5 V (iii) 6V (iv) 7 V (v) 8 V

12. Which of the following is related to the magnitude of the induced emf?
(i) Biot-Savart law (ii) Lenz's law
(iii) Ampere's law (iv) Fleming's right-hand rule (v) Faraday's law

13. A 'L' long metal rod AC can slide on the wires LM and KN which are connected by a resistance R. The magnetic field B is pointing into the paper. If the rod AC moving with the speed V, what would be the current pass through the rod?




(i) BL V (ii) B LV /R (iii) $B^2L^2$ V (iv) $B^2L^2$ V / R (v) $B^2L^2$ $V^2$/ R

14. Give the SI unit of the magnetic flux density (B)
(i) Ampere (A) (ii) Tesla (T) (iii) Weber (Wb) (iv) Gauss (G)
(v) Newton (N)

15. Which device operates based on the principle of electromagnetic induction?
(i) Battery (ii)Transformer (iii)Resistor
(iv)Capacitor (v) Diode

16. Which of the following describes the currents $I_B$ and $I_C$ in the saturation mode of an NPN bipolar junction transistor (BJT)?
(i) $I_B$ is negligible, and $I_C$ is high (ii) $I_B$ is high, and $I_C$ is negligible
(iii) Both $I_B$ and $I_C$ are high (iv) Both $I_B$ and $I_C$ are zero
(v) $I_B$ is zero, and $I_C$ is high

17. How many OR gates are required to realize the following Boolean expression.

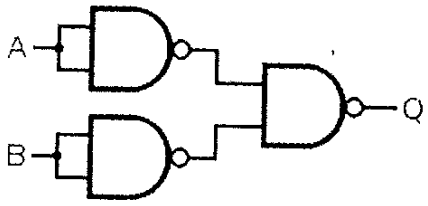
$Z = A.B + B$

(i) 4 (ii) 5 (iii) 3 (iv) 2 (v) 1

18. Which of the following is known as an universal gate?

(i) NAND (ii) OR (iii) X-OR (iv) AND (v) NOT

19. The output (Q) of the logic circuit shown in the figure will be

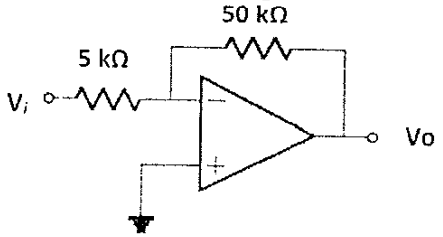



(i) A.B (ii) A+B (iii) 0 (iv) 1 (v) $A \oplus B$

20. Which of the following characteristics is NOT an ideal property of an operational amplifier (opamp)?

(i) Infinite open-loop gain (ii) High input capacitance
(iii) Infinite bandwidth (iv) Zero output impedance
(v) None of above

21. Calculate the gain for the following Op-amp circuit.

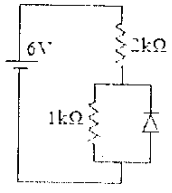


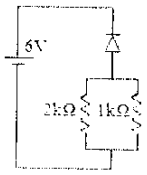

(i) -10 (ii) 10 (iii) -11 (iv) -0.02 (v) 100

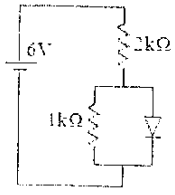
22. Given a transistor in a common emitter configuration with a current gain (β) of 200 and a collector current of 20 mA, determine the base current.

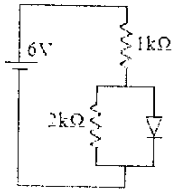
(i) 0.75 mA (ii) 0.3 mA (iii) 0.1 mA (iv) 7.35 mA (v) 15 mA

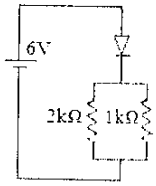
23. Which one of the following circuits draws the smallest current from the 6 V cell?

(i)



(ii)



(iii)



(iv)



(v)


24. Which of the following describes the main application of a Zener diode?
    (i) Voltage regulation
    (ii) Current amplification
    (iii) Light emission
    (iv) Rectification
    (v) Signal mixing

25. Which of the following are minority charge carriers in npn Bipolar Junction transistor?
    (i) Holes
    (ii) Electrons
    (iii) Neutrons
    (iv)Both Holes and Electrons
    (v) Both Neutrons and Electrons

## Part II

- **Answer Four (4) Questions only.**

**Question 01**

**A.** **(i)** State the Ohm's law with the relevant graph **(05 Marks)**

**(ii)** A 60 W headlamp bulb lights up using a 12 V car battery. Determine the current flowing and the resistance of the bulb (assume the resistance of the connecting wires of the circuit is negligible) **(05 Marks)**

**B.**

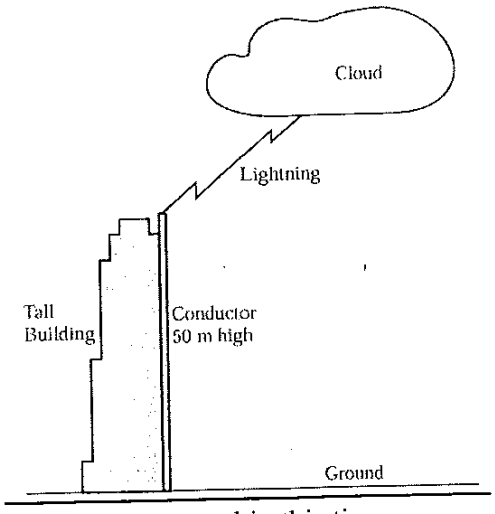
**(i)** Describe, how a potentiometer is used to find the internal resistance of a cell **(05 Marks)**

**(ii)** A cell is balanced with a potentiometer and the equilibrium length is 60 cm. A resistance of 40 Ω is connected between the ends of the cell and the balanced length is 58 cm. Calculate the internal resistance of the cell. **[05 Marks]**

**(ii)** A moving coil galvanometer has an internal resistance of 2 Ω and indicates full scale deflection when a current of 300 mA flows through it. This meter is converted to an ammeter having a full-scale deflection for a current of 1.5A. Determine the reading of the new instrument when it measured 0.9 A **[05 Marks]**

**Question 02**

**A.** A lightning stroke passes between a cloud and a lightning conductor attached to a tall building. A very large current of 20 000 A passes for $4.0 \times 10^{-4}$ S.



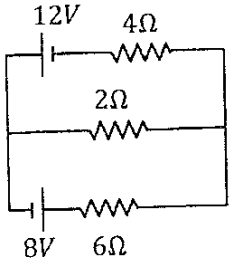

**(i).** Calculate the charge flowing to the ground in this time **(03 Marks)**

**(ii).** The lightning conductor is 50 m high and has a cross-sectional area of $1.0 \times 10^{-3}$ m$^2$. It is made from copper which has a resistivity of $1.7 \times 10^{-8}$ Ω m. Calculate the resistance of the lightning conductor. **(05 Marks)**

**(iii).** Hence calculate the potential difference between the top and bottom of the current-carrying lightning conductor. **(05 Marks)**

**(iv).** If lightning strikes a tree such that there is the same current through it as in the conductor, then a much larger potential difference exists between the top and bottom of the tree. Provide a detailed explanation for this phenomenon. **(02 Marks)**

**B.** Consider the following circuit consist of 2 Ω, 4 Ω and 6 Ω resistors connected with 12V and 8V batteries.




**(i).** Calculate the current through 2 Ω, 4 Ω and 6 Ω resistors using Kirchhoff laws. **(06 Marks)**

**(ii).** Find the voltage drop through 2 Ω resistor **(04 Marks)**

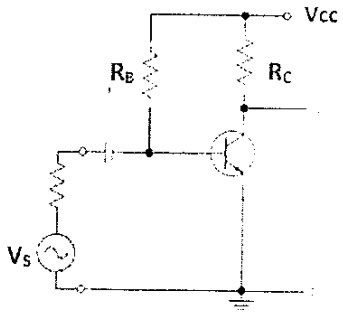
**Question 03**

**A.**

**(i).** Briefly explain about the operation modes of a bipolar junction transistor in common emitter configuration. **(05 Marks)**

**(ii).** Describe the working principle of a transistor as a switch. **(05 Marks)**

**B.** Consider the following transistor circuit in common emitter configuration. ($R_B$ =1MΩ, $R_C$ =2 kΩ, β=100 and Vcc= 10 V)




**(i)** Calculate the base current ($I_B$) **(05 Marks)**

**(ii)** Calculate the collector current ($I_C$) **(05 Marks)**

**(iii)** Calculate the maximum collector current (Ic_max) when the transistor in the saturation mode **(05 Marks)**

**Question 04**

**A.** A closed square wire loop of 4 cm a side is placed in horizontal plane. The resistance of the loop is 2 x $10^{-3}$ Ω. The loop is situated in a magnetic field of strength 0.50 T directed vertically downwards. When the field is switched off, it is decreased to zero in 0.6 s.

**(i).** What would be the induced electro motive force (EMF)? **(04 Marks)**

**(ii).** Calculate the induced current in the loop **(04 Marks)**

**(iii).** Calculate the energy produced in the loop **(04 Marks)**

**B.** A transformer is 100 % efficient. It has 200 turns on the primary coil and 3000 turns on the secondary coil. The input AC voltage is 55 V.

**(i).** Show that the output voltage is about 800 V. **(05 Marks)**

**(ii).** **Calculate** the current in the secondary coil when the current in the primary coil is 0.50 A. **(05 Marks)**

**(iii).** One purpose of having an iron core in a transformer is to wrap the wires around. What other important purpose does it serve? **(03 Marks)**

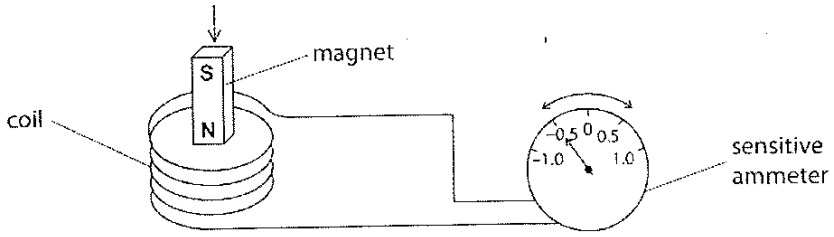
**Question 05**

**A**

**(i)** State the "Faraday Law" and "Lenz Law" in electromagnetic induction.

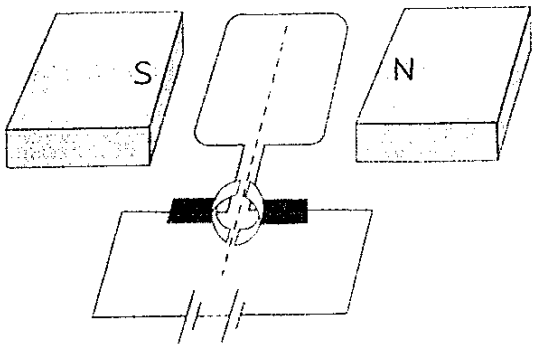
**(05 Marks)**

**(ii)** The following diagram shows a permanent magnet moving into a coil of wire. The coil of wire is attached to a sensitive ammeter.




The moving magnet and the coil of wire are producing an electric current. The magnitude and direction of the current can be changed in a number of ways. **Describe** changes that can be made to produce different currents and the effect of each change. **(05 Marks)**

A. Simplified d.c motor design consists of a coil of wire and positioned two magnets as shown in following diagram. It has a coil which spins between the ends of a magnets.




**(i).** State the directions of the magnetic field lines and the direction the current is flowing in the coils **(05 Marks)**

**(ii).** Determine whether the coil will be rotating clockwise or anticlockwise. **(05 Marks)**

**(iii).** What is the piece of equipment used to keep the coil moving? **(05 Marks)**

**Question 06**

**A.**

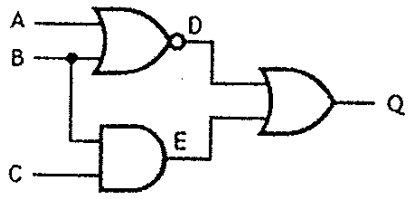
**(i) Simplify** the following Boolean expression using DeMorgan's theorem.

$$F = (\overline{\overline{X} + \overline{Y}})$$

**(05 Marks)**

**(ii) Write** the Boolean expression at the output of each gate in the following circuits

**(05 Marks)**




**B.** You are tasked to design a safety system to protect elephants and other animals from accidents on railway tracks in Sri Lanka. The system uses three sensors: an infrared sensor (I) to detect animals, a vibration sensor (V) to detect the presence of a train, and an ultrasonic sensor (U) to detect large objects (like elephants) near the tracks. Each sensor outputs a binary signal (0 or 1). Design a combinational circuit that meets the following conditions:

**Condition:** The output should be 1 (trigger the alarm) if an animal is detected on the tracks (infrared sensor is active) and either a train is detected (vibration sensor is active) or a large object (elephant) is detected (ultrasonic sensor is active)

**(i) Complete** the truth table for given condition and Derive the Boolean expression from the truth table.

**(10 marks)**

| I | V | U | O |
|---|---|---|---|
| 0 | | | |
| 0 | | | |
| 0 | | | |
| 0 | | | |
| 1 | | | |
| 1 | | | |
| 1 | | | |
| 1 | | | |

**(ii) Draw** the suitable logic circuit using AND, OR, NOT gates to trigger the alarm

**(05 marks)**

** END **