University of Ruhuna

Bachelor of Science (General) Degree Level II (Semester I) Examination

July - 2023

Subject: Physics

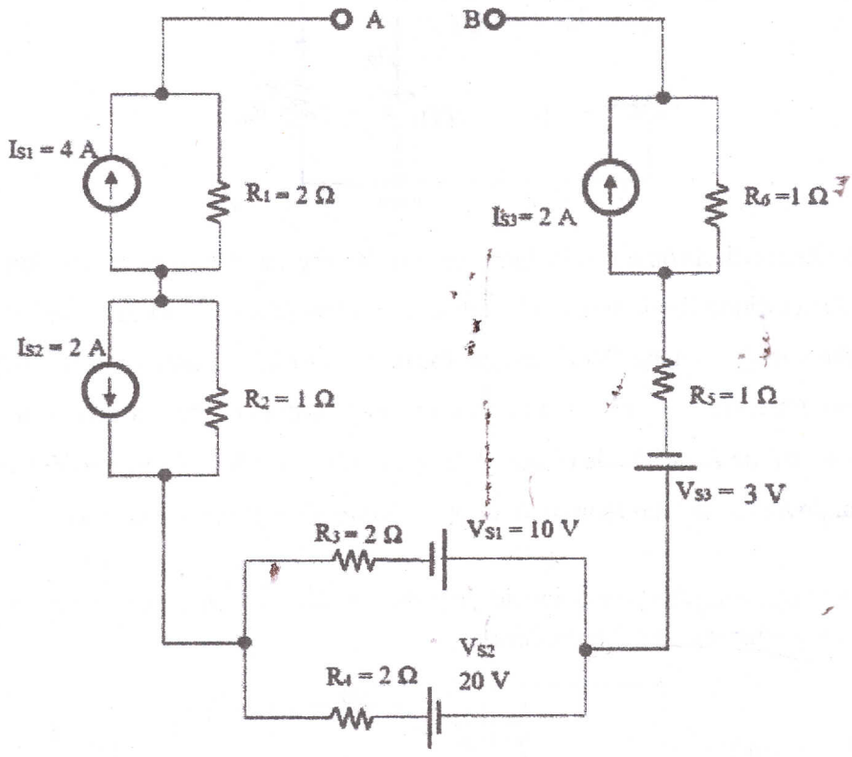
Course Unit: PHY 2112

PART B - 1 hour & 15 minutes

Answer FIVE questions only.

All symbols have their usual meaning.

1. Consider the circuit shown below.



(a) Use source conversions to find the Thevenin's equivalent circuit across **A** and **B** terminals. **[4 Marks]**

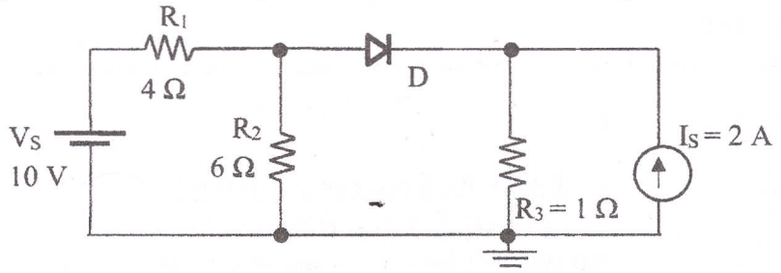
(b) If a load resistor (R_L) is connected across **A and B** terminals, derive expressions for voltage across and current through the load resistor in terms of V_{TH}, R_{TH} and R_L. **[2 Marks]**

(c) Hence, find the maximum voltage across and maximum current through a load resistor. **[2 Marks]**

(d) What would be the value of R_L to deliver the maximum power from the circuit to a load resistor and find the maximum power? **[2 Marks]**

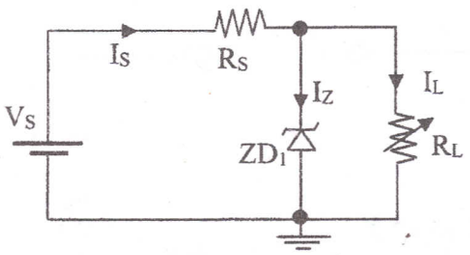
2.

(a) Find the voltage across and current through the diode given in the following circuit using the constant voltage drop model of the diode (assume that diode cut-in voltage of the diode (V_{D0}) is 0·7 V)



[5 Marks]

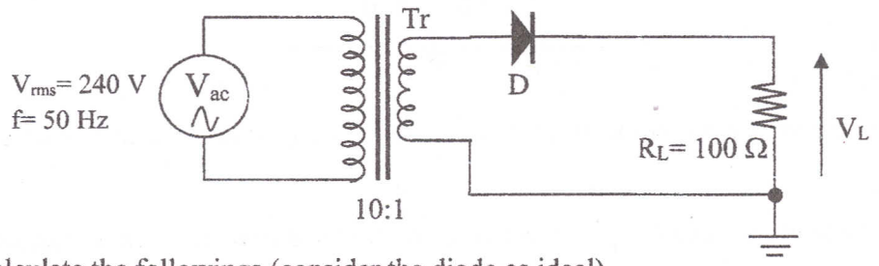
(b) Answer the following parts considering the circuit given below. Use the constant voltage drop model of a Zener diode.



(a) If the Zener diode operates in the reverse active region, derive an expression for the current through the Zener diode (I_Z) in terms of V_S, Rs, I_L and V_{Z0} (Zener breakdown voltage). **[3 Marks]**

(b) If the supply voltage (V_S) changes from 15 V to 25 V, estimate the sustainable maximum and minimum current for the load resistor that can be drawn without disrupting the voltage regulation process of the Zener diode (Take, if Rs = 100 Ω, V_{Z0} = 5 V, minimum Zener current for the reverse breakdown is 1mA and maximum power dissipation of the Zener diode is 1 W). **[2 Marks]**

3. Answer the following questions considering the rectifier circuit given below. Neglect the resistance of the secondary winding of the transformer.



(a) Calculate the followings (consider the diode as ideal).

i The peak value of the voltage across R_L, **[2 Marks]**

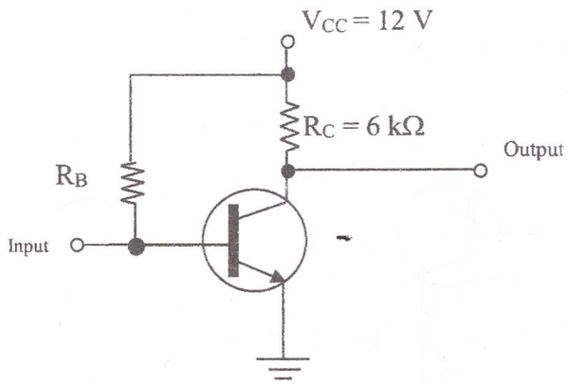
ii The rms value of the voltage across R_L, **[1 Marks]**

iii Value of the d.c. component of the voltage across R_L, **[2 Marks]**

iv rms value of the a.c. components of the voltage across R_L **[2 Marks]**

(b) Sketch the wave pattern of the voltage across the load resistor (R_L) if the polarity of the diode is reversed. **[3 Marks]**

4. Consider the following biasing circuit of a common emitter transistor amplifier circuit. ($\beta = 100$, $V_{CE\,(SAT)} = 0$ V, and V_{BE} is negligible for this transistor).

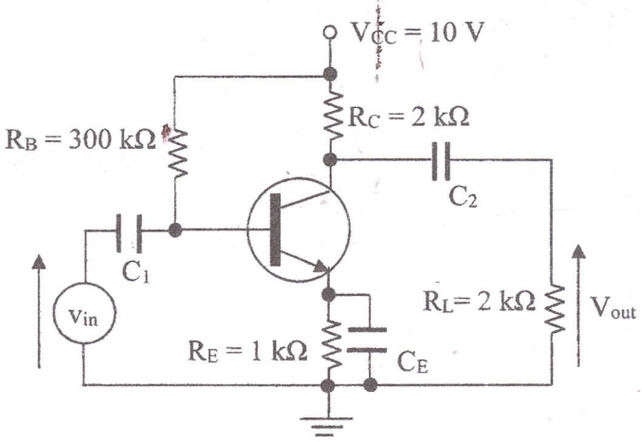


(a) What value should the V_{CE} (the voltage across collector to emitter) be held to obtain the distortion-free maximum output signal? **[2 Marks]**

(b) Calculate the appropriate value for R_B to maintain the value of V_{CE} that mentioned in **part (a)** above. **[4 Marks]**

(c) What will be the value of V_{CE} and I_C with the same R_B calculated above if R_C is replaced by a 5 kΩ resistor? **[4 Marks]**

5. Consider the following amplifier circuit (take $\beta = 100$)



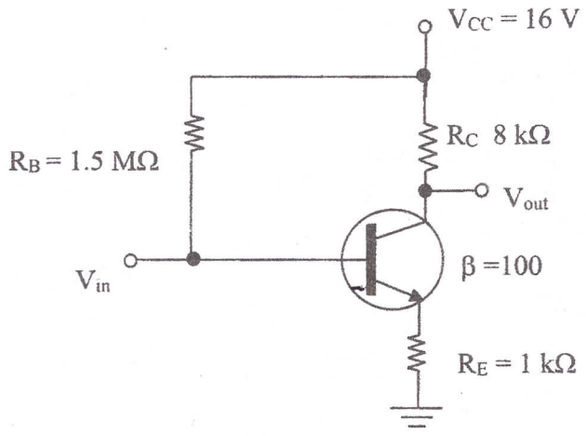
(a) What is the configuration of this transistor amplifier? **[Marks 2]**

(b) Calculate I_E of the above circuit. (Assuming V_{BE} is very small and $I_E \approx I_C$). **[Marks 3]**

(c) Draw the ac equivalent circuit for the above circuit. Hence, find the alternating current (ac) voltage gain.

Take emitter intrinsic resistance, $r_e' = \frac{25\ mV}{I_E}$). **[Marks 5]**

6. Write down the expression of the closed-loop gain for a negative feedback amplifier by defini terms. [2 Ma



(a) Derive an expression for the closed-loop gain of the above negative feedback amplifier in ter of R_C, R_E and emitter intrinsic resistance (r_e') [3 Mark

(b) Using the above expressions, calculate the open-loop gain and feedback fraction of t amplifier. [Take $r_e' = \frac{25\,mV}{I_E}$, common emitter current gain of the transistor (β) is 100, an V_{BE} is negligible.] [3 Marks

(c) If the open-loop gain of the above feedback amplifier changes by 25 % due to a temperatur variation, find the percentage change in closed-loop gain. [2 Marks]

7.

(a) Prove the following identities using Boolean algebra.

i. $A \cdot (A + A \cdot B) + \bar{A} \cdot B = A + B$ [3 Marks]

ii. $\overline{\bar{A} + A \cdot \bar{B}} = A \cdot B$ [3 Marks]

(b) Simplify the following expression using a Karnaugh-Map (K-Map).

$X = A \cdot B \cdot \bar{C} + B \cdot C \cdot \bar{D} + \bar{A} \cdot B \cdot \bar{C} \cdot \bar{D} + \bar{A} \cdot B \cdot \bar{C} \cdot D$ [4 Marks]

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