BITS, PILANI – DUBAI
DUBAI INTERNATIONAL ACADEMIC CITY

YEAR III INSTR C364 – ANALOG ELECTRONICS

Comprehensive Exam **Date: 21 May 2009**
Max marks: 50 **Weightage: 25%** **Time allowed: 3 hours**
Note: This Question Paper contains 8 Questions and has 3 pages. **Answer ALL questions**

Q1. In the circuit of Figure 1, both the diodes are identical. The I_D–V_D forward characteristic for each diode is given by an equation of the form $V_D = V_{D0} + R_F.I_D$, where $V_{D0} = 0.6V$ and $R_F = 0.2\Omega$.

(i) Determine the input voltage V_I required to produce an output voltage $V_o = 0.7$ V.

(ii) Sketch the forward diode characteristic.

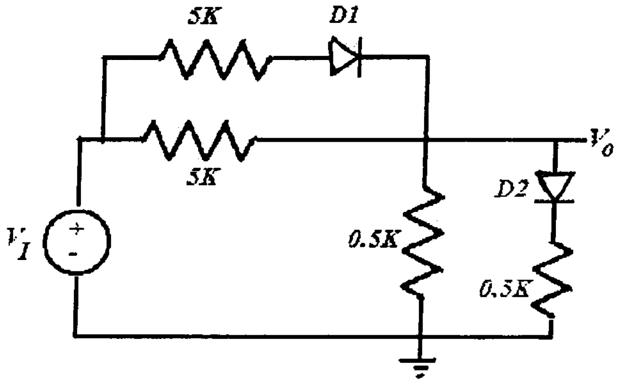

Figure 1

(6 marks)

Q2 For an ideal opamp circuit shown in Figure 2, determine the frequency for which the amplifier voltage gain is minimum. Assume that the input is given by $V_S = V_m$ Sin ωt. Hence determine the minimum gain.

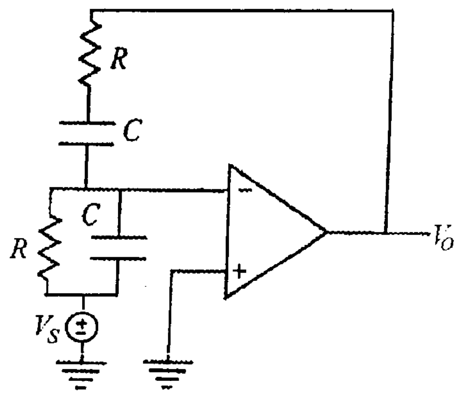

Figure 2

(7 marks)

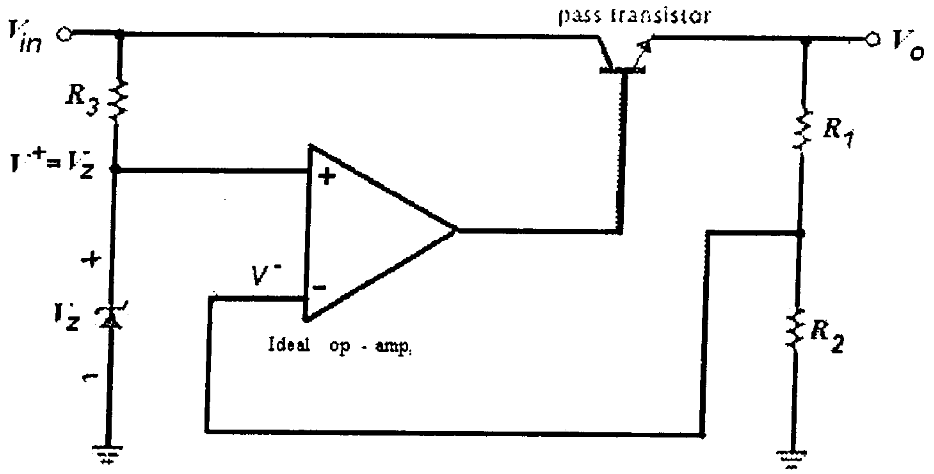

Figure 4

(8 marks)

Q7 (a) Distinguish between Class A, Class B and Class AB power amplifiers.

(b) Show that the maximum power conversion efficiency of a Class A power amplifier is limited to 25%.

(c) What is the main drawback of a Class B amplifier and how it can be overcome?

(5 marks)

Q8. An IC temperature sensor LM35 delivers an output 10 mV/°C. Three such sensors are placed in three corners of a room. The outputs of the three sensors are used as inputs to the noninverting opamp shown in Figure 5. If R_2 is 1 KΩ, calculate the value of R_1 to be used so that the composite output V_o determines the average of the temperatures measured by the three sensors.

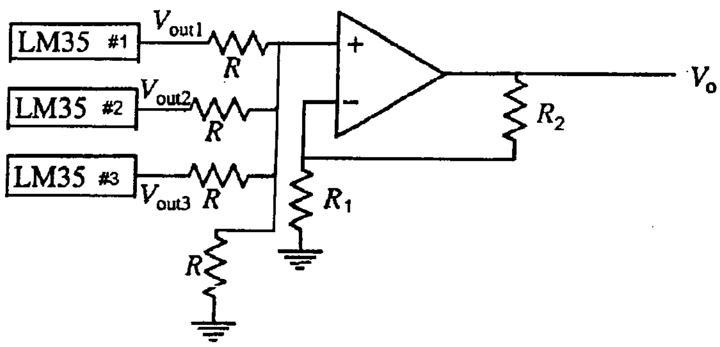

Figure 5

(5 marks)

END OF PAPER

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Test 2 **Date: 30 April 2009** **Max marks: 30** **Weightage: 15%**

Answer ALL questions Open Book **Time allowed: 50 minutes**

Q1. Write down the voltage transfer function for the circuit of Figure1

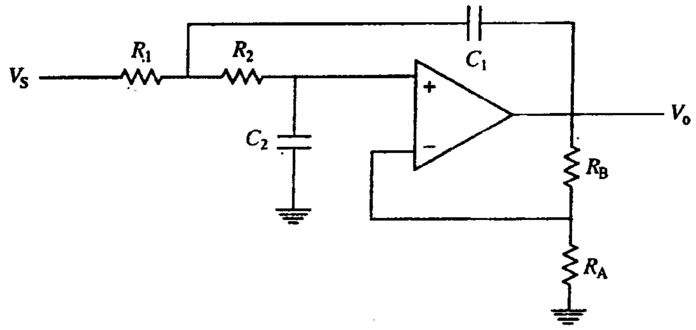

Figure 1

(a) When all resistances are expressed in MΩ and all capacitors in μF, it is observed that the numerical values of R_1, R_2, R_A, C_1 and C_2 are same. Design the circuit to provide a corner frequency of $\omega_c = 200$ rads/s and a maximally flat response.

(b) What is the low-frequency voltage gain for the circuit?

(c) Does the property of the circuit change if all resistances are increased by a factor of 2 and all capacitors decreased by a factor of 2? Explain your answer.

(7 marks)

Q2 An input signal $v_i = \cos\omega t$ is to be converted to an output signal $v_o = \cos 3\omega t$. Explain how this can be realized using two 2-input analog multipliers, and an opamp difference amplifier.

(5 marks)

Q3 Explain the function of the circuit shown in Figure 2 on page 2. Describe the nature of the output V_o. It is desired to obtain a periodic output with a frequency of 1 KHz by choosing 1KΩ for R and 1μF for C. Determine the ratio R_1/R_2 needed to achieve this. If the circuit of Figure 2 is modified to include an integrator after the output V_o, how would the resulting output from the integrator look like?

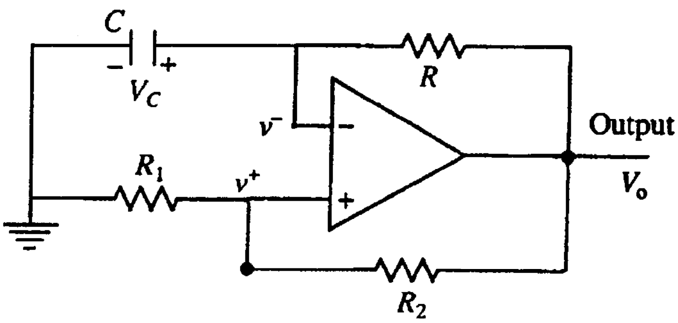

Figure 2

(6 marks)

Q4. Load regulation in a power supply is defined by

$$\% \text{ Regulation} = [(V_{NL} - V_{FL}) / V_{FL}] \times 100\%$$

where V_{NL} and V_{FL} refer to output voltage with no load and full load respectively. In Figure 3, a full load current is achieved when a load resistance of 120 Ω is connected. The voltmeter reads 51 V and 50 V with the switch S open and closed respectively. What is the % load regulation of the power supply? Determine the output resistance of the power supply.

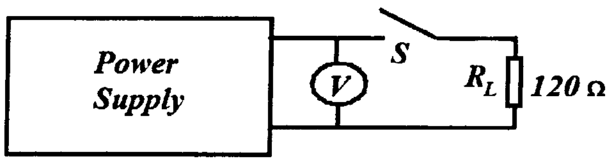

Figure 3

(6 marks)

Q5. The circuit of Figure 4 is designed to provide maximum load current when the load resistance is 10 Ω and the input voltage is at its maximum of 24 V. Under this condition, the transistor has a base-emitter voltage of 0.7 V and a β of 50. The zener diode is held at a breakdown voltage of 10.7 V with a current of 10 mA flowing through it. Determine the resistance R used in the circuit and the power dissipation P_D in the transistor.

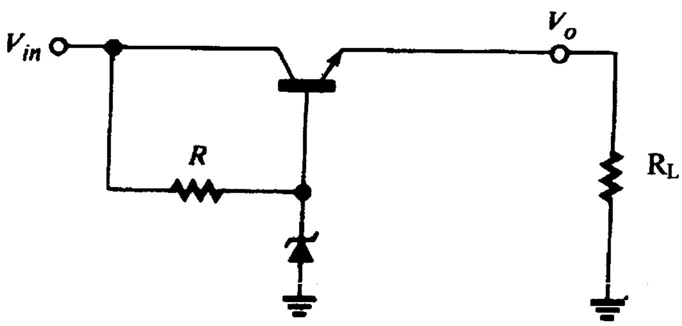

Figure 4

(6 marks)

END OF PAPER

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Test I (CLOSED BOOK) Date: 22 March 2009 Max marks: 40 Weightage: 20%

Answer ALL questions **Time allowed: 50 minutes**

Q1. The diode D in the circuit of Figure 1(a) has a forward characteristic as shown in Figure 1(b).

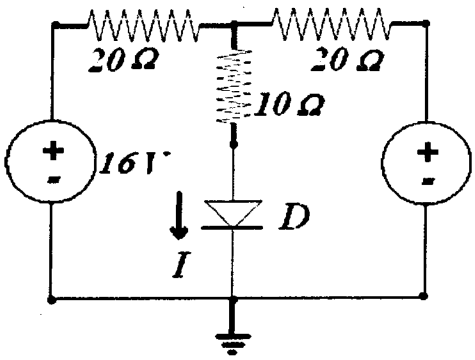


Figure 1(a)

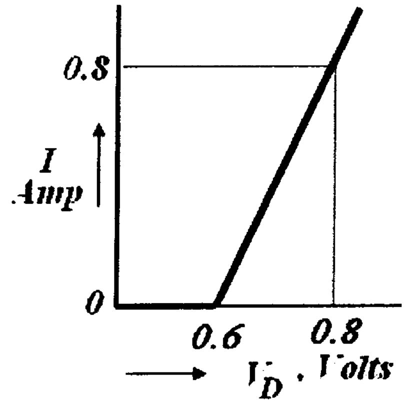


Figure 1(b)

① (a) What is the limiting voltage across the diode, above which the diode acts as a simple resistor R_F? 0·6 V

③ (b) Determine the value of R_F and hence draw the DC equivalent model for the diode D. 0·25 Ω

④ (c) Calculate the current I through the diode. 0·76 A

(8 marks)

Q2 An opamp circuit shown in Figure 2 is used to record small changes in the resistance R of a strain gauge transducer. Assume that the opamp has an input offset voltage V_{OS} = 1 mV.

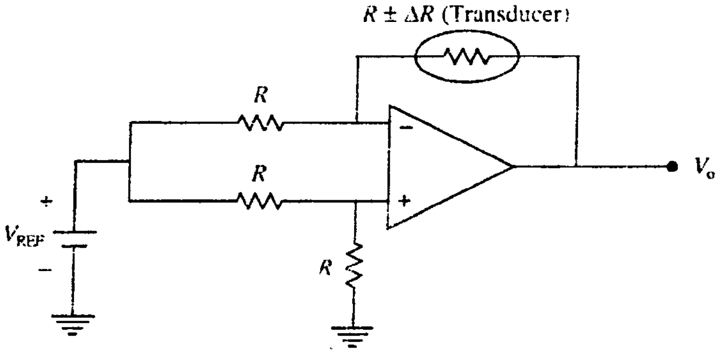


Figure 2

(a) What is the output V_o of the amplifier when the strain gauge has a nominal resistance R? 2 mV ⑤

(b) Arising from changes in the resistance of the transducer from (R -ΔR) to (R +ΔR), the output voltage is expected to change from V_{o1} to V_{o2}. Derive an expression for the sensitivity of response ($\Delta V_o/\Delta R$) in terms of R and V_{REF}. What should be done to increase the sensitivity?

Derive $S = \frac{\Delta V_o}{\Delta R} = \frac{V_{ref} - 2V_{os}}{R}$ ④ (10 marks)

$S\uparrow \Rightarrow R\downarrow, V_{ref}\uparrow, V_{os}\downarrow$ ①

P.T.O

3. Figure 3 shows an electronic thermometer that converts a current I_T from a temperature transducer to a voltage that is read by a 0 – 1V voltmeter for a range of temperature from 0 to 100°C. The transducer delivers a current 1 μA /Kelvin through it.

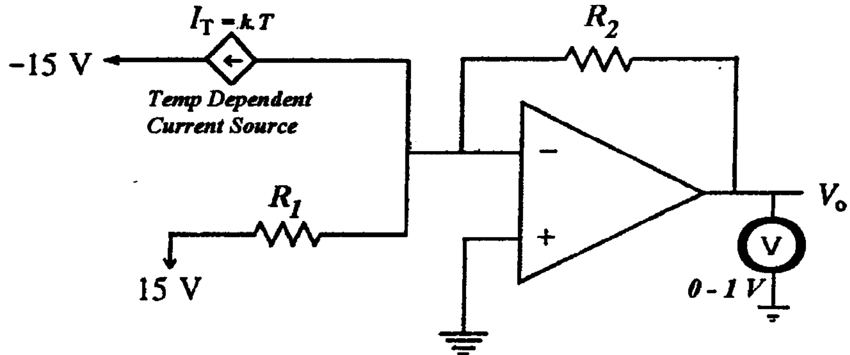


Figure 3

(a) Assuming that the opamp is ideal, determine the values of the resistances R_1 and R_2 so that the voltmeter indicates a full scale deflection for a temperature of 100°C and zero deflection for a temperature of 0°C. $R_1 = 54.945K$ (2) $R_2 = 10k$ (2)

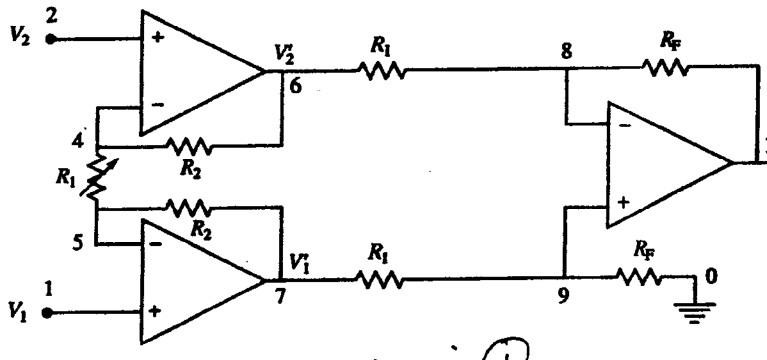
(b) The opamp in the circuit above is replaced by a non ideal opamp having the following input offset parameters: V_{OS} = 10 mV, $I_+ = I_-$ = 5 μA. Determine the effect of these offset parameters on the output voltage as read by the voltmeter. If a temperature of 30°C is to be actually measured, how much will the thermometer indicate?

$V_o|_{V_{OS}} = 11.8mV$ (3) $V_o|_{I_+} = 0V$ (3) $V_o|_{I_-} = 50mV$ (3)

(1) (15 marks)

Total output at 0°c = 61.8 mV ≡ 6.18°C 30°c will read 36.18°c (1)

4. State the basic requirements of an instrumentation amplifier. In the circuit of Figure 4, derive an expression for the output in terms of the inputs V_1 and V_2. (2)



$V_o = \left(1 + \frac{2R_2}{R_1}\right) \cdot \frac{R_F}{R_I} (V_1 - V_2)$ (2)

To provide adjustable gain (1)

Figure 4

First half of above ckt (1)
CMRR = 1 + 2R2/R1

What is the role of the potentiometer R_1? Identify the input buffer stage of the instrumentation amplifier and determine the CMRR of the buffer stage. Why it is preferable to keep R_1 small compared to R_2? so that CMRR can be increased (1)

(7 marks)

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Quiz 3 **Max marks: 10** **Weightage: 5%** Answer ALL questions

Q1. An unregulated power supply (URPS) is the input to a regulated power supply (RPS) whose output is connected to a load R_L as shown in Figure 1(a) below. The URPS and the zener diode have the characteristics shown in Fig 1(b) and (c). V_{zmin} is the minimum zener voltage needed to start breakdown. The maximum current through the zener is limited to 100 mA. In the breakdown region, the zener is modeled with a resistance $r_Z = 2\ \Omega$.

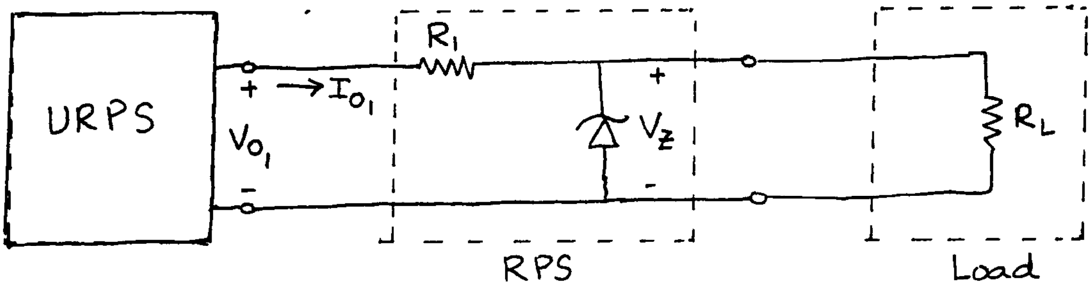

Figure 1(a)

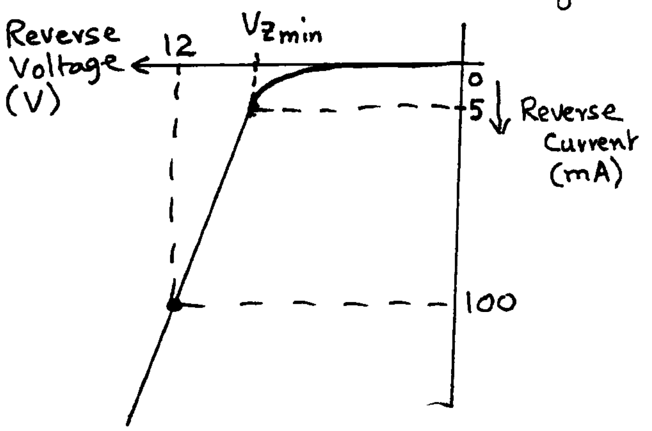

Figure 1(b)

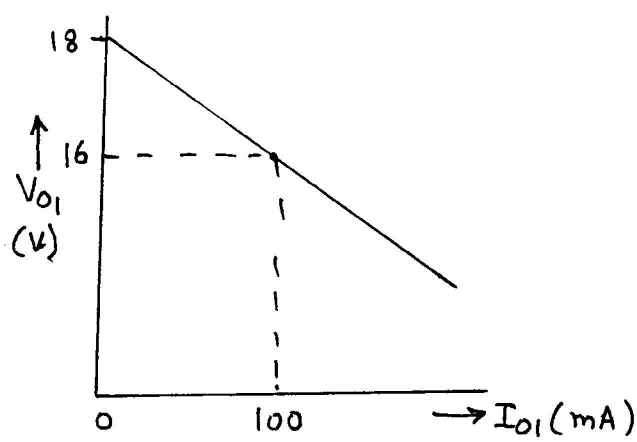

Figure 1(c)

Determine V_{zmin}. Also calculate the Resistance R_1. What is the maximum load current through R_L and the corresponding value of R_L that will keep the zener at the verge of breakdown?

(6 marks)

Q2. Draw the circuit diagram of a simple emitter follower voltage regulator comprising of one transistor, one zener diode and resistances. Explain the function of the circuit.

(4 marks)

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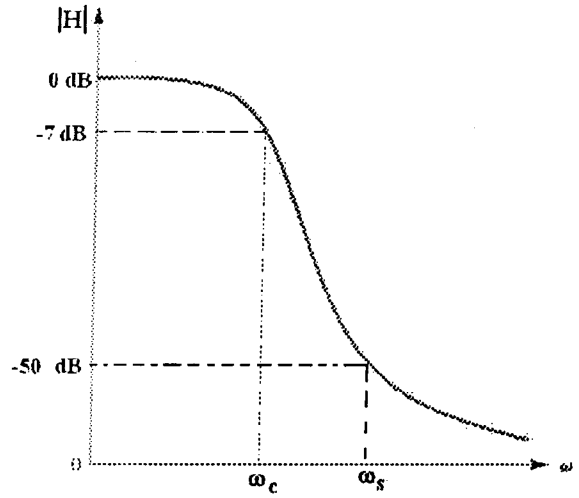
Quiz 2 Time: 15 minutes Total marks 10. Weightage: 5%

Answer All Questions.

Q1. The transfer function and response of a certain hypothetical low pass filter are is shown below

$$|H(j\omega)| = \frac{1}{\sqrt{1+\varepsilon^2\left(\frac{\omega}{\omega_c}\right)^{2N}}}$$



(a) What does ε represent?

(b) If ω_s represents the edge of the stop band above which the response is considered insignificant and rejected, determine the value of ε and the minimum value of the order N of the filter that would be needed, if the ratio of the stop band edge frequency and the corner frequency is 1.2

(c) Use the expression for the transfer function to determine the roll off rate of the low pass filter.

(5 marks)

Q2.

Using op amps, draw two schematic diagrams, one block representing a log amplifier and another, an antilog amplifier. Show how the two blocks can be integrated to obtain an analog multiplier that gives an output xy for two inputs x and y.

It is desired to convert an input signal V_{in} = 2Sin wt to an output signal V_{out} = 10Sin (3wt) by incorporating the above analog multipliers. Draw a schematic diagram for the circuit.

(5 marks)

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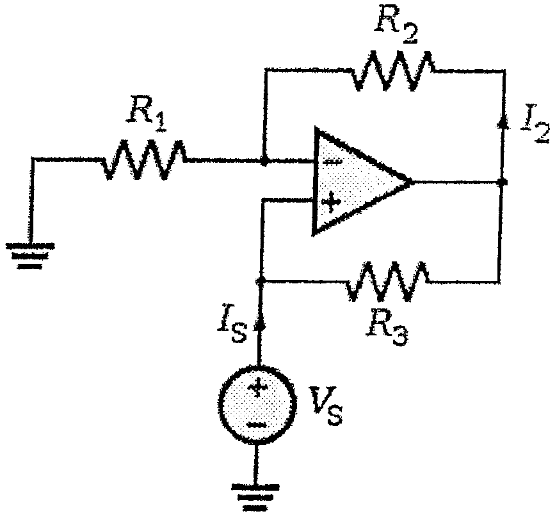
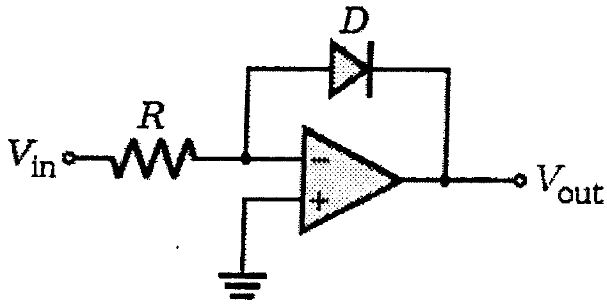
III YEAR INSTR C364 ANALOG ELECTRONICS 2008-2009 SEMESTER 2
QUIZ 1 3 MAR 2009 FULL MARKS 10 WEIGHTAGE 5%

Q1. For the following circuit, determine the input impedance V_s/I_s and hence state any application of the circuit.



5 marks

Q2. It is required to construct a logarithmic amplifier where the output is a logarithmic function of input. Check if the following circuit will satisfy the requirement. Assume that the diode acts as an open circuit under reverse bias, while under forward bias V_D, it carries a current $I_D = I_S.\exp[V_D/V_T]$. Assume ideal op amp. Is there any constraint on the applied input voltage ? Explain



5 marks