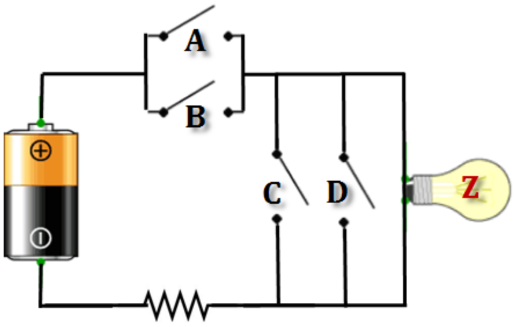
Q.3 (a) Derive a logical expression for the switch circuit shown in figure below.



(5 Marks)

Work your answer to Q.3(a) in the space below.

$$Z = (A + B) \cdot \overline{C} \cdot \overline{D} = B \cdot \overline{C} \cdot \overline{D} + A \cdot \overline{C} \cdot \overline{D} = \overline{A} \cdot B \cdot \overline{C} \cdot \overline{D} + A \cdot \overline{B} \cdot \overline{C} \cdot \overline{D} + A \cdot B \cdot \overline{C} \cdot \overline{D}$$

(b) The truth table below shows the relationship between inputs **A, B, C** and **D**, and output **Z**. Find **Z** in terms of **A, B, C** and **D** in the Sum-of-products (SOP) form.

A	B	C	D	Z
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	1
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	1
1	0	0	1	0
1	0	1	0	0
1	0	1	1	0
1	1	0	0	1
1	1	0	1	0
1	1	1	0	0
1	1	1	1	0

(5 Marks)

Give your answer to Q.3(b) in the space below.

$$Z = \overline{A} \cdot B \cdot \overline{C} \cdot \overline{D} + A \cdot \overline{B} \cdot \overline{C} \cdot \overline{D} + A \cdot B \cdot \overline{C} \cdot \overline{D}$$

(c) Simply the expression obtained in (b) using Karnaugh map.

(5 Marks)

Give your answer to Q.3(c) in the space below.

	AB	$A\overline{B}$	$\overline{A}\,\overline{B}$	$\overline{A}B$
CD	0	0	0	0
$C\overline{D}$	0	0	0	0
$\overline{C}\,\overline{D}$	1	1	0	1
$\overline{C}D$	0	0	0	0

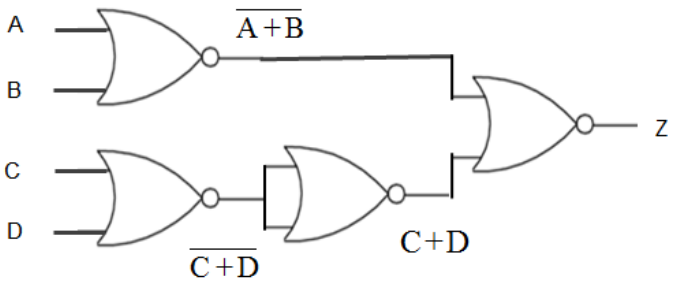
$$Z = B\cdot\overline{C}\cdot\overline{D} + A\cdot\overline{C}\cdot\overline{D} = (A+B)\cdot\overline{C}\cdot\overline{D}$$

(d) Implement the logical expression obtained in (c) using no more than 4 two-input NOR gates (i.e., each NOR gate only has two input channels).

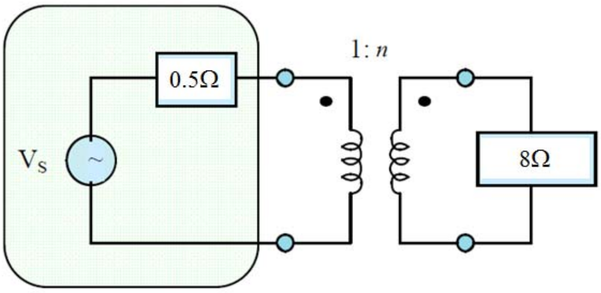
(10 Marks)

Give your answer to Q.3(d) in the space below.

$$Z = \overline{\overline{(A+B)\cdot\overline{C}\cdot\overline{D}}} = \overline{\overline{(A+B)}+\overline{\overline{C}\cdot\overline{D}}} = \overline{\overline{(A+B)}+(C+D)} = \overline{\overline{(A+B)}+\overline{\overline{(C+D)}}}$$



Q.4 (a) A sound system with a loudspeaker can be represented in a circuit diagram below. Assume that the internal resistance of the source is 0.5Ω, and the resistance of the load is 8 Ω.



(i) Find an appropriate transformer turns ratio, which results in impedance matching.

(4 Marks)

(ii) Given $v_s(t) = 230\sqrt{2}\cos(\omega t)$ V and with the transformer turning ratio obtained in (i), find the average powers consumed by the load and by the internal resistor.

(4 Marks)

(iii) Given $v_s(t) = 230$ V and again with the transformer turning ratio obtained in (i), find the actual powers consumed by the load and by the internal resistor.

(4 Marks)

(iv) For both (ii) and (iii), determine the power consumed by the transformer.

(4 Marks)

Give your answer to Q.4(a) in the space below. If necessary, continue on the next three pages.

(i) $R_{\text{equivalent}} = \dfrac{8}{n^2} = 0.5 \quad \Rightarrow \quad n^2 = \dfrac{8}{0.5} = 16 \quad \Rightarrow \quad n = 4$

(ii) $V = 230 \quad \Rightarrow \quad I = \dfrac{V}{0.5 + 0.5} = 230 \quad \Rightarrow \quad p_{\text{load}} = p_{\text{in}} = |I|^2 R = 230^2 \times 0.5 = 26,450\text{W}$

(iii) $p_{\text{load}} = 0$ (It is a DC source, which cannot be transformed to the load).

$p_{\text{in}} = \dfrac{230^2}{0.5} = 105,800\text{W}$

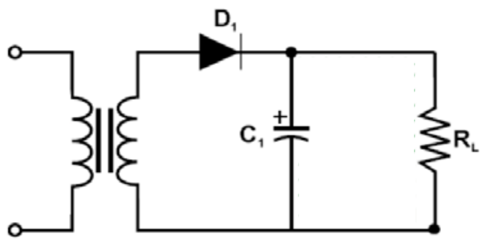
(iv) Power consumed by the transformer = 0. Ideal transformer does not consume power.

(b) Suggest a DC power supply circuit that can be used to step down the electric source from the mains (230V AC) to power up your laptop, which takes 5V DC. Draw the circuit with necessary components. Will you use your design for your own laptop? Why or why not?

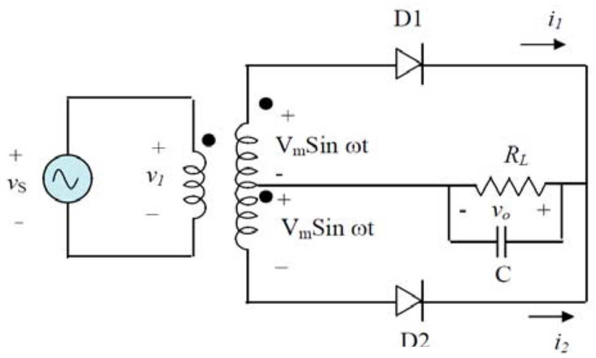
(9 Marks)

Give your answer to Q.4(b) in the space below.

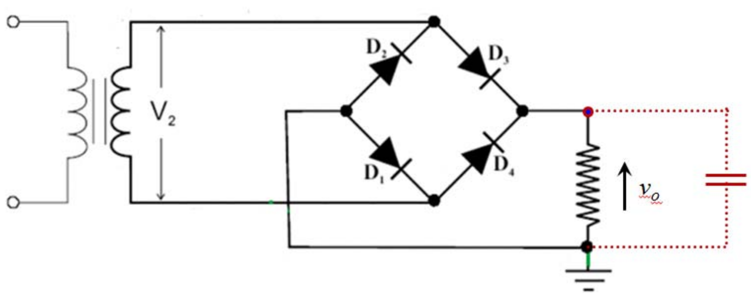
Any of the following circuits can do the job:



(a)



(b)



(c)

For (a) and (c), the transformer turn ratio is $230\sqrt{2}:5 = 65:1$. For (b), it is 65:2.

The capacitance of the capacitor should be sufficiently large.

Yes. The circuit has the capability of providing 5V to the laptop even though there is no protection in the circuit. One should use it with caution.