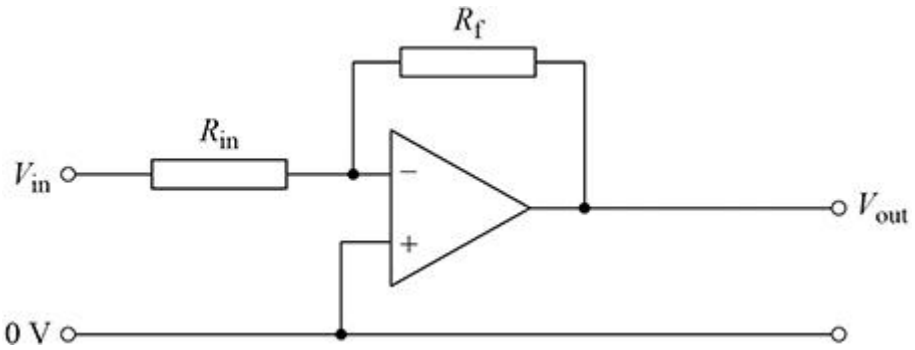
Name of the Student:_____
Max. Marks : 22 Marks **Time : 22 Minutes**

Q1.

Figure 1 shows a circuit containing an ideal operational amplifier. A signal V_{in} is applied to one of the amplifier inputs.

Figure 1



(a) Draw an **X** on the circuit in **Figure 1** to indicate a virtual earth point.

(1)

(b) Show that the closed loop voltage gain for the amplifier in **Figure 1** is given by:

$$\frac{R_f}{R_{in}} = -\frac{V_{out}}{V_{in}}$$

State any assumptions made in your answer.

assumptions _____

_____

(2)

(c) **Figure 2A** shows the input signal V_{in} that is applied to the circuit in **Figure 1**.

Figure 2A

Downloaded from www.merit-minds.com

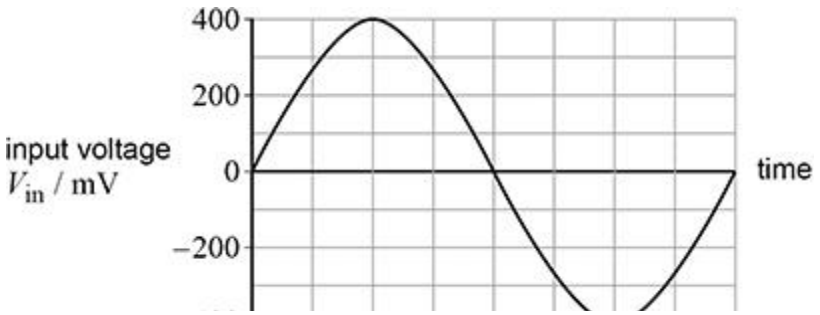
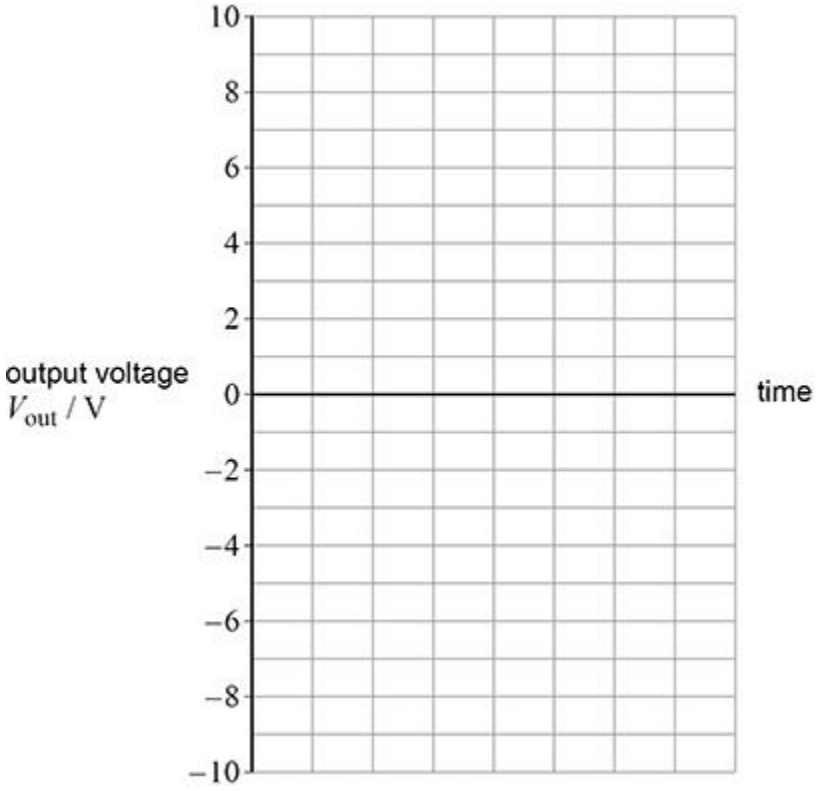


Figure 2B



The circuit in **Figure 1** has a closed loop gain of -20 and has power-supply voltages of $\pm$ 6.0 V.

Draw, on **Figure 2B**, the output waveform from the operational amplifier circuit over the same time interval as that shown on **Figure 2A**.

(2)

(d) A student converts the circuit in **Figure 1** into one that will add two input signals V_1 and V_2.

The new circuit produces an output voltage V_{out} so that:

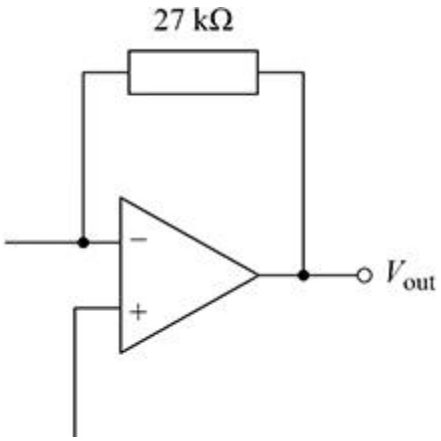
$$V_{out} = -(1.5V_1 + 0.75V_2)$$

The circuit is to include a 27 kΩ feedback resistor.

Complete **Figure 3** to show the circuit that the student constructs.
Annotate your circuit with the values of any additional components.

Figure 3

Downloaded from www.merit-minds.com

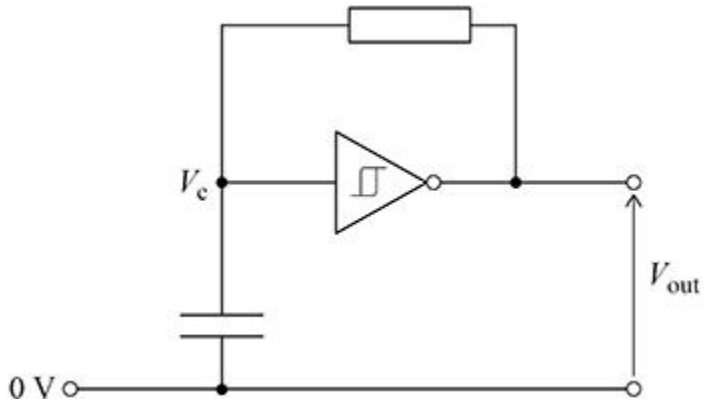


(3)
(Total 8 marks)

Q2.

Figure 1 shows a type of NOT gate called a Schmitt Trigger. This is connected to a capacitor of capacitance C and a resistor of resistance R to make an oscillator circuit. The circuit is used to produce continuous clock pulses.

Figure 1



V_{out} switches HIGH or LOW when the input voltage V_c passes through one of two trigger voltage values.

The output voltage V_{out} switches to:

- LOW when V_c rises and reaches the upper trigger voltage V_U
- HIGH when V_c falls and reaches the lower trigger voltage V_L.

(a) Initially the capacitor is uncharged and V_c is at 0 V.

Explain the sequence of actions of this circuit as the output goes through one full cycle. The first two stages have been done for you.

You should refer to the RC circuit in **Figure 1** and to V_U and V_L in your answer.

Stage 1: Since V_c is LOW, the output is HIGH.

Stage 2: The capacitor now charges through the resistor, making V_c rise.

Stage 3: _____

Downloaded from www.merit-minds.com

Stage 4: _____

_____

_____

Stage 5: _____

_____

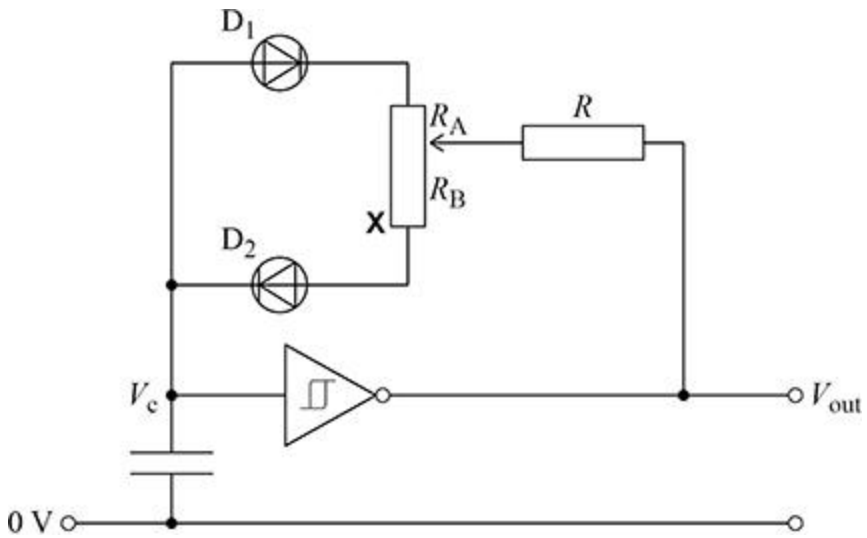
_____

(3)

(b) **Figure 2** shows the oscillator circuit after it has been modified by the addition of:

- two diodes D_1 and D_2
- a potential divider that has a total resistance value of (R_A + R_B).

Figure 2



In this particular circuit:

- the time t_H for the output signal to be HIGH is given by $t_H = 0.7C\ (R + R_B)$
- the time t_L for the output signal to be LOW is given by $t_L = 0.7C\ (R + R_A)$.

The slider of the potential divider is moved towards **X**, as shown in **Figure 2**.

State and explain the effect of this change on:

- the mark-to-space ratio (t_H : t_L)
- the pulse rate frequency (PRF).

mark-to-space ratio _____

_____

_____

Downloaded from www.merit-minds.com

PRF _____

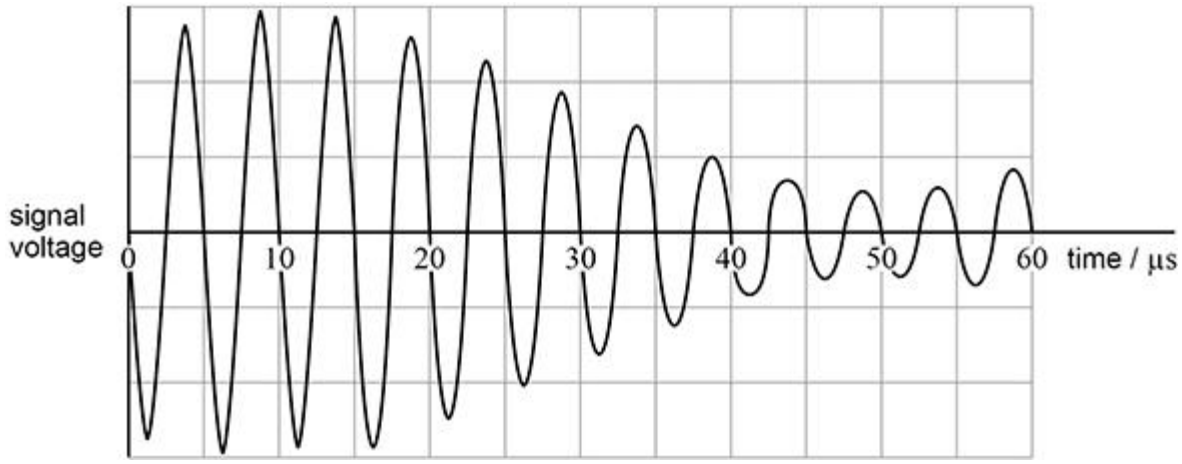
(4)

(Total 7 marks)

Q3.

The figure below shows the output signal from the tuner circuit of a radio receiver.

The radio carrier wave is amplitude modulated by a single-frequency test tone.



(a) Determine the frequency, in kHz, of the carrier wave.

frequency of carrier wave = _____ kHz

(1)

(b) Determine the frequency, in kHz, of the test tone.

frequency of test tone = _____ kHz

(2)

Downloaded from www.merit-minds.com

(c) State **one** advantage of using frequency modulation (FM) rather than amplitude modulation (AM).

_____

_____

(1)

(d) The frequency range of the FM radio band in the UK is 88 to 108 MHz.

The FM stations are allocated centre frequencies that start at 88.100 MHz and are separated by 200 kHz.

Calculate the maximum number of stations allowed within the range.

maximum number of stations = _____

(1)

(e) A radio station broadcasting on FM transmits a maximum audio frequency of 15 kHz and has a frequency deviation of $\pm$ 75 kHz.

Deduce whether the radio station fits the FM bandwidth allocation in the UK.

_____

_____

_____

(2)

(Total 7 marks)

Downloaded from www.merit-minds.com