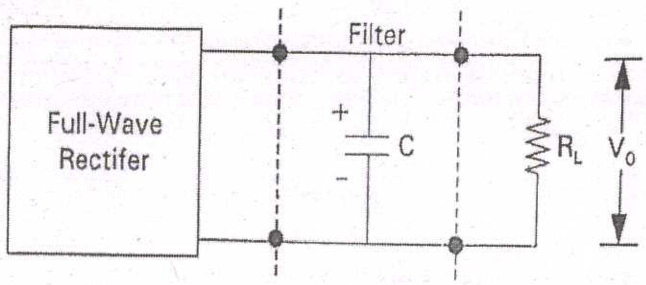
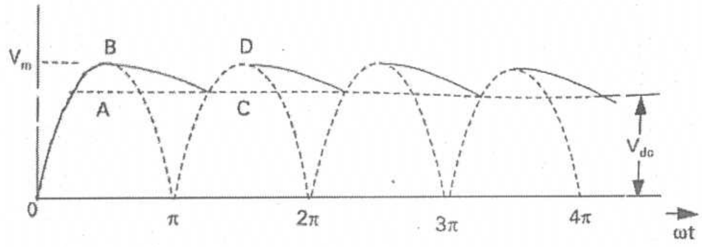
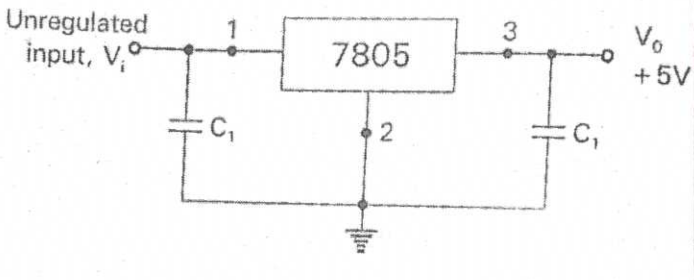
ANSWER KEY AND
SCHEME OF VALUATION

(Scoring Indicators)

Revision : 2015 Course Title : Analog Devices and Circuits		Course Code:3031		
Qst. No	Scoring Indicator	Split up score	Sub Total	Total
I	**Part A**			
(a)	Ripple factor : Ratio of the rms value of the AC component of voltage or current to the DC component in the rectifier output. OR Ripple factor , r = $\frac{rms\ value\ of\ AC\ component}{Average\ (or)\ DC\ value}$	2	2	
(b)	Resistors, inductors, capacitors, transformers (Any two)	2	2	
(c)	(Any two) 1. Current gain is less than unity. 2. High voltage gain 3. Power gain is approximately equal to voltage gain. 4. No phase reversal between input and output. 5. Very low input resistance 6. Very high output resistance.	2	2	
(d)	Tank circuit: A circuit which produces electrical oscillations of any desired frequency.	2	2	
(e)	Voltage gain of inverting op-amp , $A_V = 1+\frac{R_F}{R_1}$. Where R_F – Feedback resistance. R_1 – Input resistance.	2	2	10
II	**PART B**			
II (1)	Shunt capacitor filter: Diagram  	2		

	<u>Waveforms</u>  	2	6	
	<u>Explanation</u> The capacitance offers a low reactance path to the ac component of current. During the positive half cycle, the capacitor charges to the peak voltage Vm. Just past the positive peak, the rectifier output voltage tries to fall. But at point B, the capacitor has +Vm voltage across it. Since the source voltage becomes slightly less than Vm, the diode is reverse biased and become open circuited. The diode disconnects the source from the load. The capacitor starts to discharge through the load. This prevents the load voltage from falling to zero. The capacitor continues to discharge until the source voltage becomes more than the capacitor voltage (at point C). The diode again starts conducting, the capacitor is again charged to peak value Vm. During the time the capacitor is charging (from point C to D) the rectifier supplies the charging current. The current is maintained through the load all the time.	2		
II(2)	<u>voltage regulator using 7805 IC</u> : <u>Diagram</u>  	3	6	
	<u>Explanation</u> Pin 1 is the input terminal pin 2 the ground and pin 3 is the output terminal. The unregulated input voltage (Vi) is given to the input terminal. The output is taken from the output terminal. Filter capacitors are shown to be connected at the input and output side. The input capacitor C1 is used to cancel the inductive effects due to long distribution leads and the output capacitor C, improves the transient response.	3		

II(3) Comparison between positive and negative feedback

(Any three comparison) 6 6

Positive feedback	Negative feedback
1. The feedback signal is in same phase with the input signal.	1.The feedback signal is in phase opposition or 180 out of phase with the input signal.
2. Also called regenerative feedback.	2. Also called degenerative feedback.
3. It increases the net input to the amplifier.	3. It reduces the net input to the amplifier.
4. It increases the gain of the amplifier.	4. It reduces the gain of the amplifier.
5. It increases the noise and distortion.	5. It reduces the noise and distortion.
6. It decreases the stability of amplifier gain.	6. It improves the stability of amplifier gain.
7. Used in oscillator circuits.	7. Used in amplifier circuits.

II(4) Importance of impedance matching in power amplifiers

Explanation : 6 6

In many electronic systems the final output is in the form of sound. In such systems, the final stage has to be a power amplifier and the loudspeaker is the load for the power amplifier. The power amplifier drives the loudspeaker. The maximum power will be transferred to the loudspeaker from the power amplifier, only if the power amplifier output impedance is same as the impedance of the loudspeaker. If it is not so, the loudspeaker gets less power, though the amplifier is capable of delivering more power. So, it is possible to obtain maximum power output, impedance matching is required between the power amplifier and loudspeaker. This can be achieved by using an impedance matching network that match the loudspeaker impedance to the output impedance of the power amplifier.

II(5) Barkhausen's criterion

Explanation : 6 6

To obtain sustained oscillations in any sinusoidal oscillator circuit, certain conditions known as the "Barkhausen Criteria" must be fulfilled.

The essential conditions for maintaining oscillations are

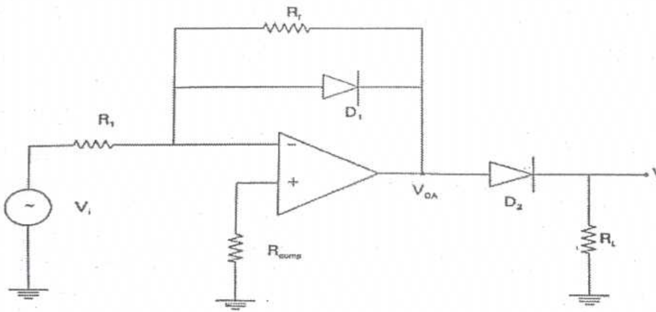
(1) $|A\beta| = 1$, i.e., the magnitude of loop gain must be equal to one.

(2) The total phase shift around the closed loop is zero (or) 360 degrees.

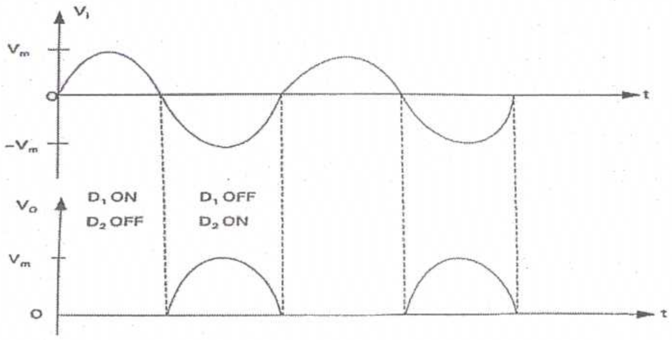
Sustained oscillations are not produced if at the oscillation frequency the magnitude of the loop gain is less than unity.

II(6) Half wave precision rectifiers 3

Diagram :



Waveforms : 1



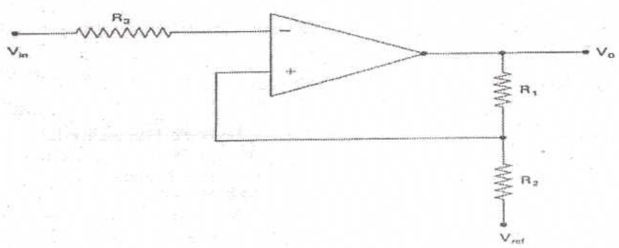
Input and output voltage waveform

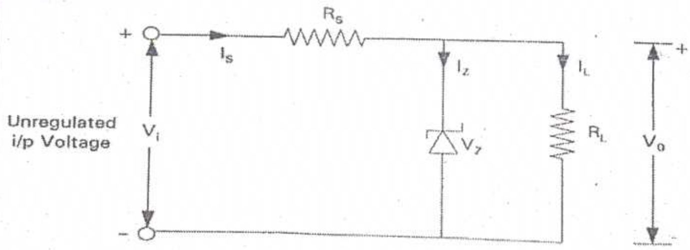
Explanation : 2 6

When V_i is positive, diode D1 conducts causing V_{OA} to go to negative by one diode drop (- 0.6 V). Hence diode D2 is reverse biased. The output voltage V_o is zero, because no current flows through R_f and the input current flows through D1. For negative input, i.e., $V_i < 0$, diode D2 conducts and D1 is off. The negative input V_i forces the OP-AMP output V_{OA} positive and causes D2 to conduct. The circuit then acts like an inverter for $R_f = R_1$ and output V_o becomes positive.

II(7) Schmitt trigger circuit using operational amplifier Diagram : 3

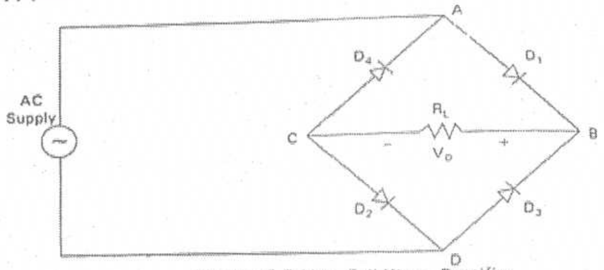
Diagram :



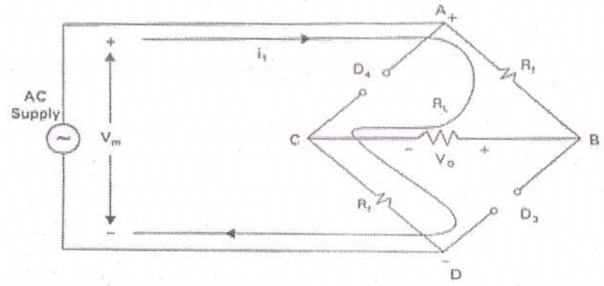
	<u>Applications</u> : (Any two) (1.5 marks each) (1) Used as a voltage comparator. (2) Used for wave shaping circuits. (3) Used for generation of a rectangular wave form from a sine wave or any other waveform. (4) Hysteresis in Schmitt trigger is valuable when conditioning noisy signals for using digital circuits.	3 3	6	42
	PART C			
III(a)	<u>Zener diode as a voltage regulator</u> <u>Diagram</u>  <u>Explanation</u> A zener has a sharp breakdown voltage under reverse bias condition. When the input voltage is greater than the breakdown voltage of the zener diode then the voltage across it is constant irrespective of the current flowing through it. This principle is used in this regulator circuit. If the load current I_L should increases , the current Iz through the zener diode decreases by the same amount in order to maintain constant current Is, This keeps the voltage drop across R, constant. Hence, the output voltage V, remains constant. If the load current decreases, the zener diode passes an extra current Iz such that the current Is is kept constant. Hence the output voltage remains constant.	4 3	7	
III(b)	<u>Bridge type full wave rectifier</u> <u>Explanation</u> During positive half cycle of the input due to the polarity of secondary voltage, the diodes D1 and D2 are forward biased and conduct, while diodes D3 and D4 are reverse biased and do not conduct. Therefore, current i, flows through diodes D1, D2 and load R_L. During negative half cycle of the input the polarities of secondary voltage gets reversed. Now the diodes D3 and D4 are forward biased and conductor, while diodes D1 and D2 are reverse biased and do not conduct. Now let i_2 is the current flowing through diodes D3, D4 and load R_L. Both the currents i, and i_2 flows through the load resistor R_L in the same direction and hence they can be added to give the total output current Therefore, a fluctuating unidirectional voltage is developed across the load R_L.	2 3		

Diagram

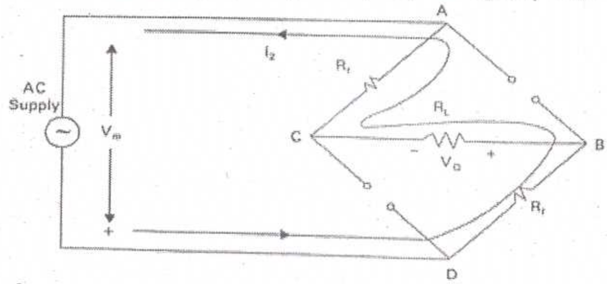
3
2*1.5=3



Circuit of Bridge Full-Wave Rectifier



During positive half cycle of input ; D_1 ; D_2 ON D_3 ; D_4 OFF.

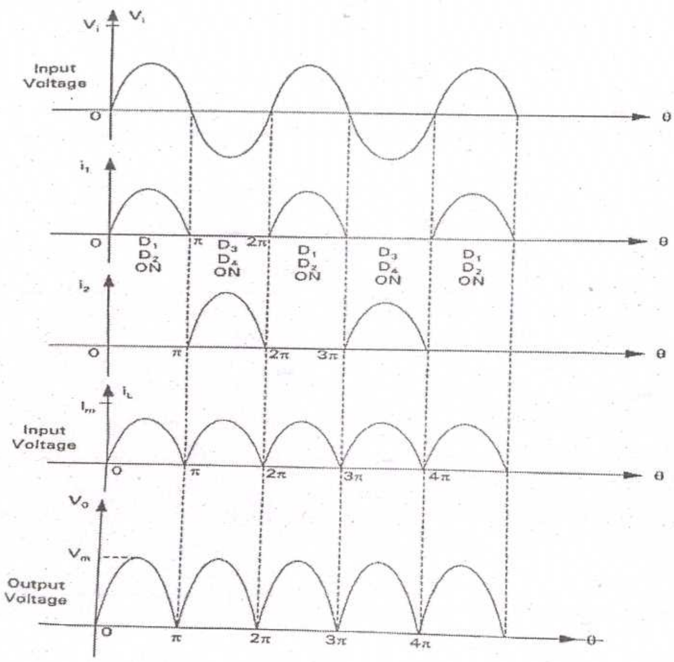


During negative half cycle of input : D_1 , D_2 OFF and D_3, D_4 ON

8

Waveforms

2

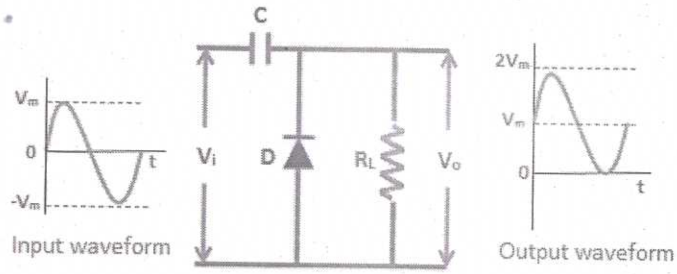


IV(a)

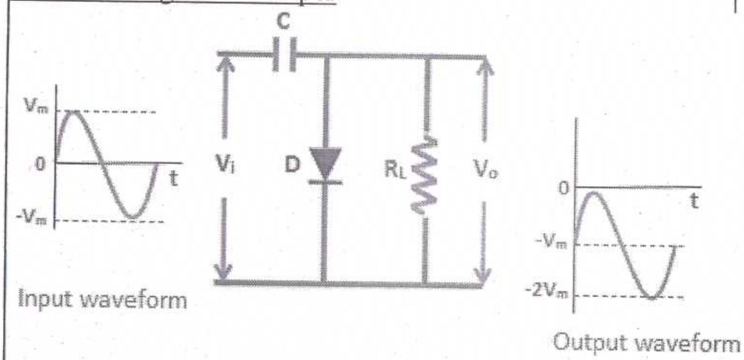
Characteristics	Half wave rectifier	Centre tap rectifier	Full wave rectifier
1.Need for centre-tapped transformer	No	Yes	No
2.No.of diodes	1	2	4
3. Maximum efficiency	40.6%	81.2%	81.2%
4.Ripple factor	1.21	0.482	0.482
5.Output frequency	f_{in}	$2f_{in}$	$2f_{in}$
6.Peak inverse voltage	V_m	$2\ V_m$	V_m
7.RMS current	$\frac{Im}{2}$	$\frac{Im}{\sqrt{2}}$	$\frac{Im}{\sqrt{2}}$
8.Average or DC current	$\frac{Im}{\pi}$	$\frac{2Im}{\pi}$	$\frac{2Im}{\pi}$

7 (Any four) — 7

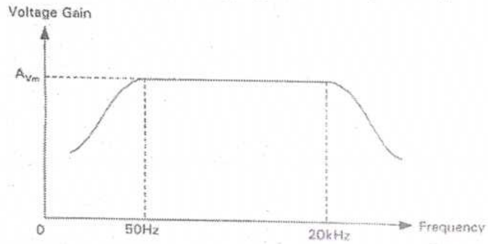
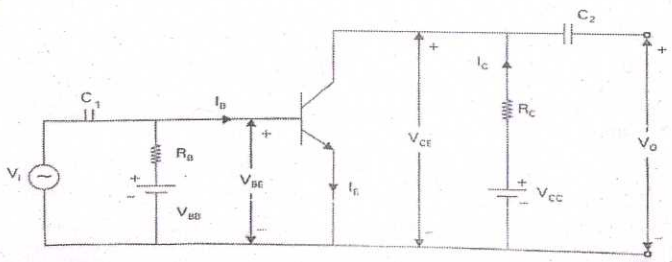
IV(b) unbiased positive clamper — 2.5

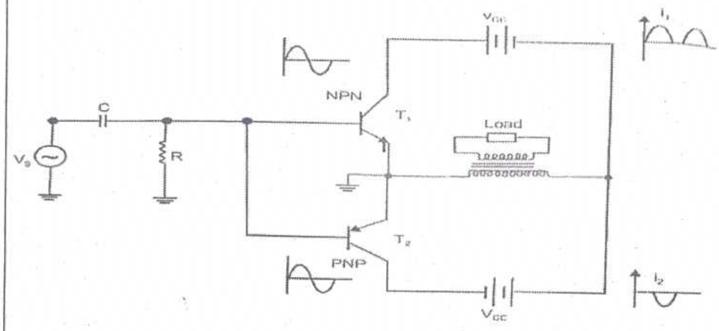
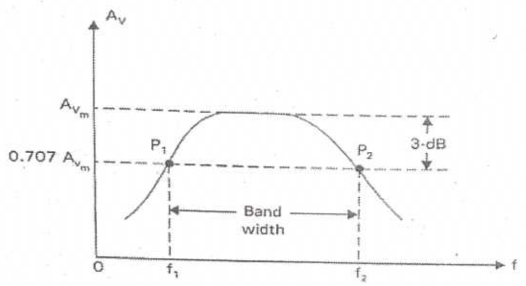


Unbiased negative clamper — 2.5 — 8



Explanation — 3

V(a)	Frequency response of RC coupled amplifier  	3	7	
	Explanation The entire frequency response will be divided into three regions. (i) At low frequencies (< 50 Hz) : The fall in the low frequency region is due to the coupling capacitance. The reactance of the coupling capacitance will be large at low frequencies. Therefore as the frequency is low the voltage drop will be more. Similarly the emitter by pass capacitor CE cannot by pass the RE effectively. Because of these two reasons, the voltage gain falls at low frequencies. (ii) At High Frequencies (> 20 kHz) : As the frequency of the input signal increases, the gain of the amplifier reduces. Several factors are responsible for this reduction in gain. Firstly, the beta of the transistor is frequency dependent. Its value decreases at high frequencies. Because of this, the voltage gain of the amplifier reduces as the frequency increases. Another important factor responsible for the reduction in gain of the amplifier at high frequencies is due to inter-electrode capacitances. Because this shunting effect, the voltage gain reduces. (iii) At mid Frequencies (50 Hz to 20 kHz) : The gain in the mid frequency range will almost be constant. This is due to the fact that the reactance of the coupling capacitor will be very small that it can be neglected. Further, the reactance of the shunting capacitance will be sufficiently large that its effect is negligible.	4		
V(b)	 	4	8	
	Explanation When a sinusoidal a.c. signal is applied at the input terminals of the circuit, during the positive half cycle the forward bias of the base-emitter junction is increased, resulting in an increase in IB. The collector current Ic is increased by p times the increase in IB. The drop Ic Rc increases, hence Vo = VcE correspondingly decreases.	4		

	Thus, in a CE amplifier a positive going input signal is converted into a negative going output signal i.e., a 180 degree phase shift is introduced between the output and input signal and further the output signal is an amplified version of the input signal .			
VI(a)		4	7	
	Explanation With no signal input, both transistors are cut - off and no collector current flows. The signal applied at the input goes to the base of both the transistors. Since the transistors are of opposite type, they conduct in opposite half - cycles of the input. During the positive half - cycle of the input signal, the NPN transistor T1 is forward -biased and conducts current. On the other hand, the PNP transistor T2 is reverse biased and does not conduct. This results in a half - cycle of output voltage across the load resistor. The other half - cycle of output across the load is provided by the conduction of transistor T2 (the transistor T1 remains cut - off) during negative half - cycle of the input.	3		
VI(b)	Frequency Response of an Amplifier	3		
	(i) Lower and upper cut-off frequencies : The frequencies at which the voltage gain reduces 1 to 0.707 of the maximum gain are known as the cut-off frequencies of the amplifier. The frequency f1 is the lower cut-off frequency and the frequency f2 is the upper cut-off frequency.	2		
	(ii) Bandwidth : The bandwidth of an amplifier is defined as the range of frequencies over which the gain is equal to or greater than	2		

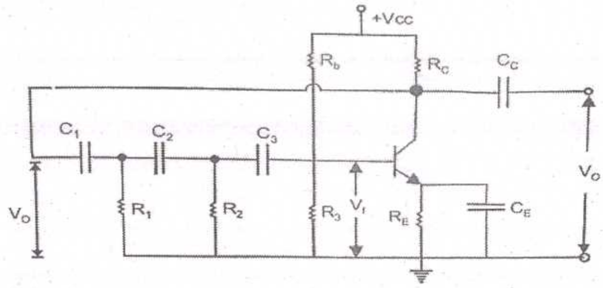
0.707 of the maximum gain.
The difference between the two cut-off frequencies is called the bandwidth of the amplifier. i.e., Bandwidth = $f_2 - f_1$

(iii)3-dB points : At cut-off frequency the voltage gain reduces to 0.707 of the maximum gain. On the dB scale this is equal to a reduction in voltage gain by 3dB. For this reason, the points P_1 and P_2 are called 3-dB points. 1

8

VII(a)

RC phase shift oscillator 4



7

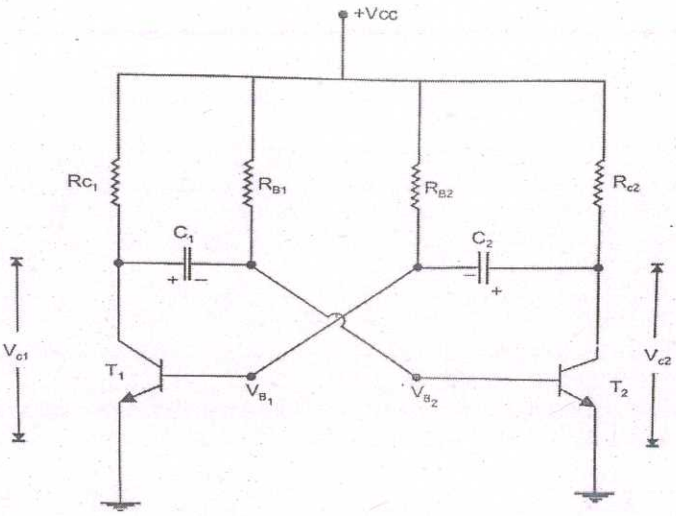
Explanation 3

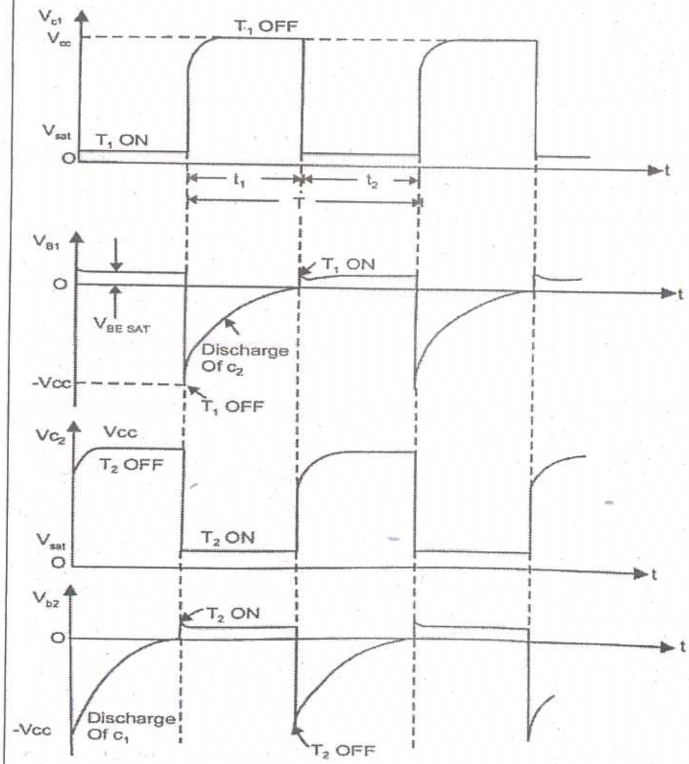
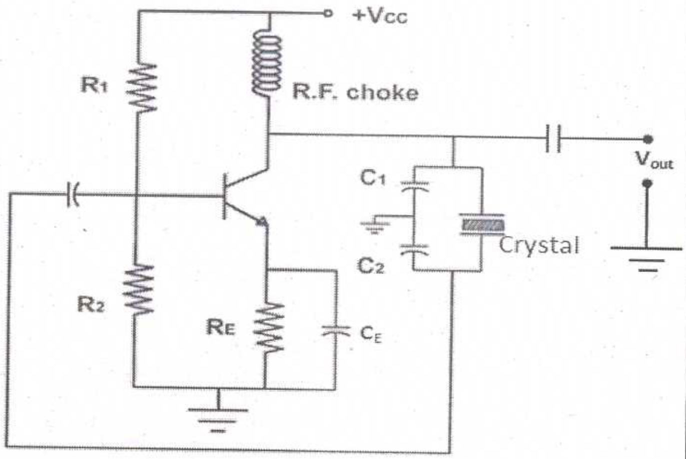
Since transistor CE amplifier produces a phase shift of 180°, and further phase shift of 180° is produced by the RC phase shift network. Thus, the total phase shift around the entire loop is 360°. The result is that the output of the transistor amplifier is returned to the input in the proper phase to produce oscillations.

Circuit Operation : When the circuit is switched on, it is set into oscillations by any random motion of electrons in elements or the transistor.. The amplified noise now drives the feed back network. This output voltage Vo of the amplifier is feed back to RC phase shift feed back network. At some particular frequency fo, the RC phase shift network provides exactly 180° phase shift.

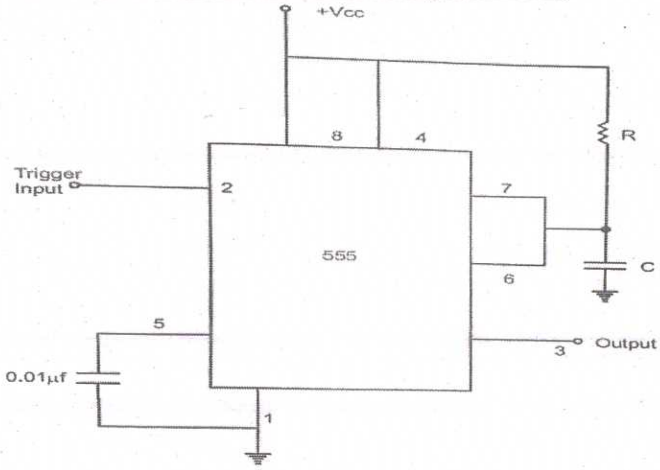
VII(b)

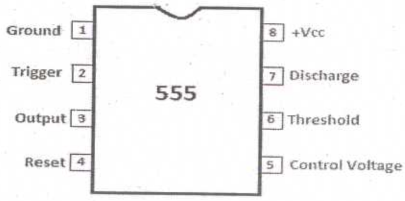
3



	Waveforms 	3	8	
	Explanation	2		
VIII(a	Crystal oscillator 	3		
	Explanation	2	7	
	Advantages 1. Excellent frequency stability. 2. Frequency is not affected by stray capacitances and transistor. 3. Quality factor is high. 4.Frequency is independent of supply voltage and temperature variation	2 (Any two)		

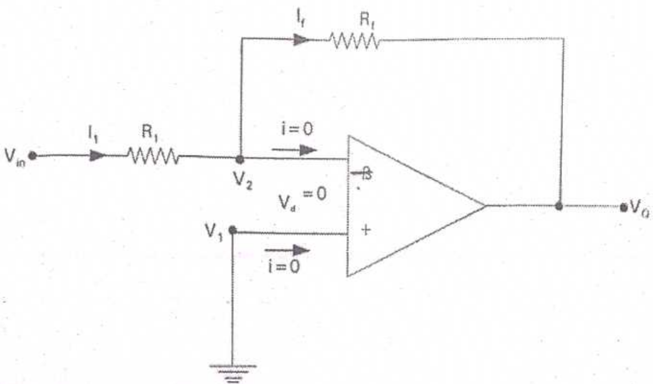
VIII(b	Monostable multivibrator circuit using IC 555.	4	8	





Explanation — 4

IX(a) — 3 — 7



Explanation & Derivation — 4

$$V_i - V_1 = I_f R_i$$

$$V_1 - V_o = I_f R_f$$

$$V_i - 0 = I_f R_i$$

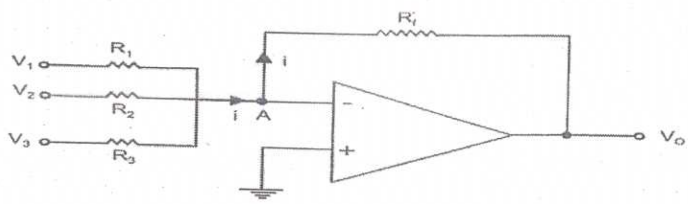
$$0 - V_o = I_f R_f$$

$$-\frac{V_o}{V_i} = \frac{I_f R_f}{I_f R_i} \Rightarrow \frac{V_o}{V_i} = -\frac{I_f R_f}{I_f R_i}$$

$$\Rightarrow \frac{V_o}{V_i} = -\frac{R_f}{R_i}$$

$$A_v = -\frac{R_f}{R_i}$$

IX(b)



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Explanation & Derivation

4

$$i = i_1 + i_2 + i_3 + \cdots\cdots + i_n$$

$$\Rightarrow i = \frac{v_1 - 0}{R_1} + \frac{v_2 - 0}{R_2} + \frac{v_3 - 0}{R_3} + \cdots\cdots + \frac{v_n - 0}{R_n}$$

$$\Rightarrow i = \frac{v_1}{R_1} + \frac{v_2}{R_2} + \frac{v_3}{R_3} + \cdots\cdots + \frac{v_n}{R_n} \cdots\cdots (i)$$

$$i = \frac{0 - v_0}{R_f} = -\frac{v_0}{R_f} \cdots\cdots (ii)$$

$$\frac{v_1}{R_1} + \frac{v_2}{R_2} + \frac{v_3}{R_3} + \cdots\cdots + \frac{v_n}{R_n} = -\frac{v_0}{R_f}$$

$$\Rightarrow v_0 = -\left(\frac{R_f}{R_1}v_1 + \frac{R_f}{R_2}v_2 + \frac{R_f}{R_3}v_3 + \cdots\cdots + \frac{R_f}{R_n}v_n\right)$$

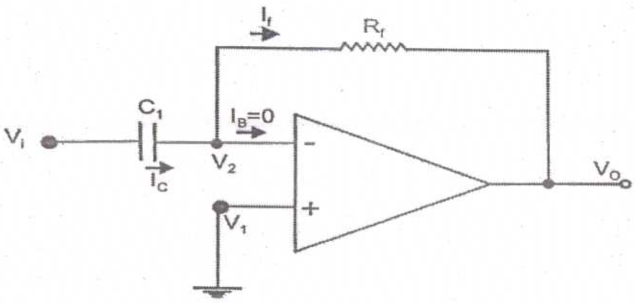
X(a) characteristics of an ideal operational amplifier

- Infinite open-loop gain $G = v_{out} / v_{in}$
- Infinite input impedance R_{in}, and so zero input current
- Zero input offset voltage
- Infinite output voltage range
- Infinite bandwidth with zero phase shift and infinite slew rate
- Zero output impedance R_{out}
- Zero noise
- Infinite common-mode rejection ratio (CMRR)
- Infinite power supply rejection ratio.

7 (Any seven)

7

X(b) Differentiator by using Opamp — 4



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Explanation and Derivation — 4

Flow of current through the capacitor can be written as

$$I_{in} = I_f$$

Where $I_f = -V_{out}/R_f$

The capacitor charge equals the voltage with capacitance times across the capacitor. Therefore the charge rate change is

$$dQ/dt = C\ dV_{in}/dt$$

But the dQ/dt is the current through the capacitor

$$I_{in} = C\ dV_{in}/dt = I_f$$

$$-V_{out}/R_f = C\ dV_{in}/dt$$

An ideal output voltage (Vout) for the operational amplifier differentiator is written as $V_{out} = -R_f C\ dV_{in}/dt$