Mid semester exam

1. A formula 1 car race is recorded digitally to obtain a 60 fps full HD video. In the video, Lewis Hamilton's car's tyre seems to have a mark on its rim that appears static. However, the car seems to be zipping through really quickly across the laps.

1.1. Based on the information above, what is the smallest non-zero value of rotations per second of Hamilton's wheel that would make it appear static?

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1.2. Upon reducing the speed, the mark on Hamilton's wheel seems to appear on two diametrically opposite ends without moving. What is the smallest rotations per second of Hamilton's wheel that could result in such a video?

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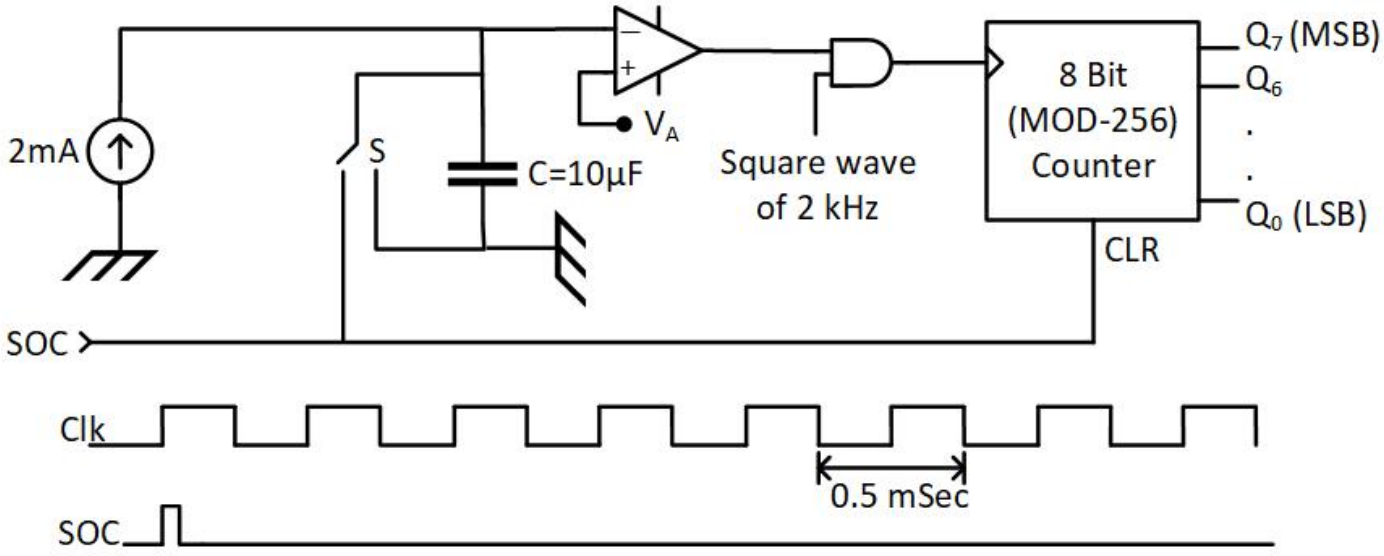
2. Question group text

2.1.
The figure below shows the simplest way of converting an analog voltage to a digital value. When SOC (Start of Conversion) pulse is applied, the switch S closes for the SOC pulse duration and discharges the capacitor instantaneously. Simultaneously the counter also clears. This SOC pulse is synchronized with the clock and its width is neglected for calculations. If the analog voltage $V_A = 2V$. What will be the bit sequence held by the counter at the end of conversion? Assume that the op-amp is ideal. What is the range of V_A for which the output will be 00000011?



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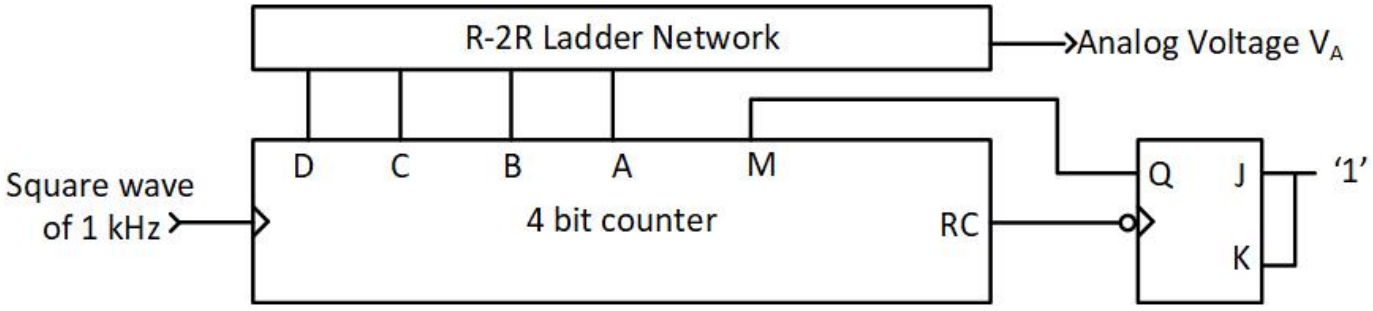
2.2.

If the mode input $M = 1$, 4 bit counter works as a MOD-16 down counter, and when $M = 0$, it works as MOD-16 up counter. The signal at the RC (ripple clock) is a low level pulse equal in width to the low level portions of the clock input when all the outputs (A,B, C, and D) of the counter are either 1111 or 0000 and it is High otherwise. Sketch the output voltage waveform and the signal at Pin-M of the circuit shown in the figure below if the full-scale output of the DAC is 7.5V. Explain the operation of the circuit. The figure should be labelled and the transition of the signal at pin-M with respect to the output voltage V_A should be shown. Assume that initially 4 bit counter-IC and J-K Flip-flop are cleared.



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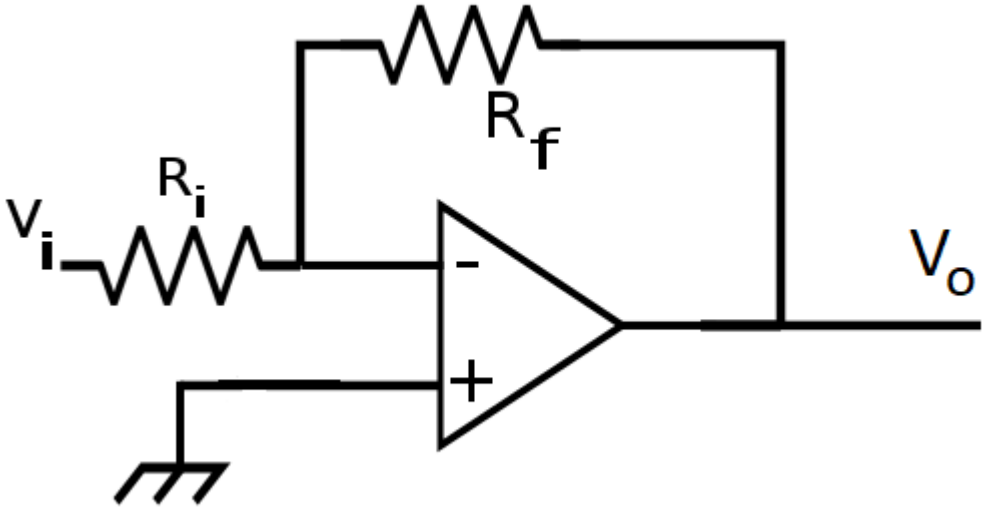
3.

It was told in the class that ideal operational amplifier has infinite input impedance. Consider that this ideal operational amplifier is used as an inverting amplifier as shown in figure. What is the input impedance of this network? Show steps as to how you arrived at your result.



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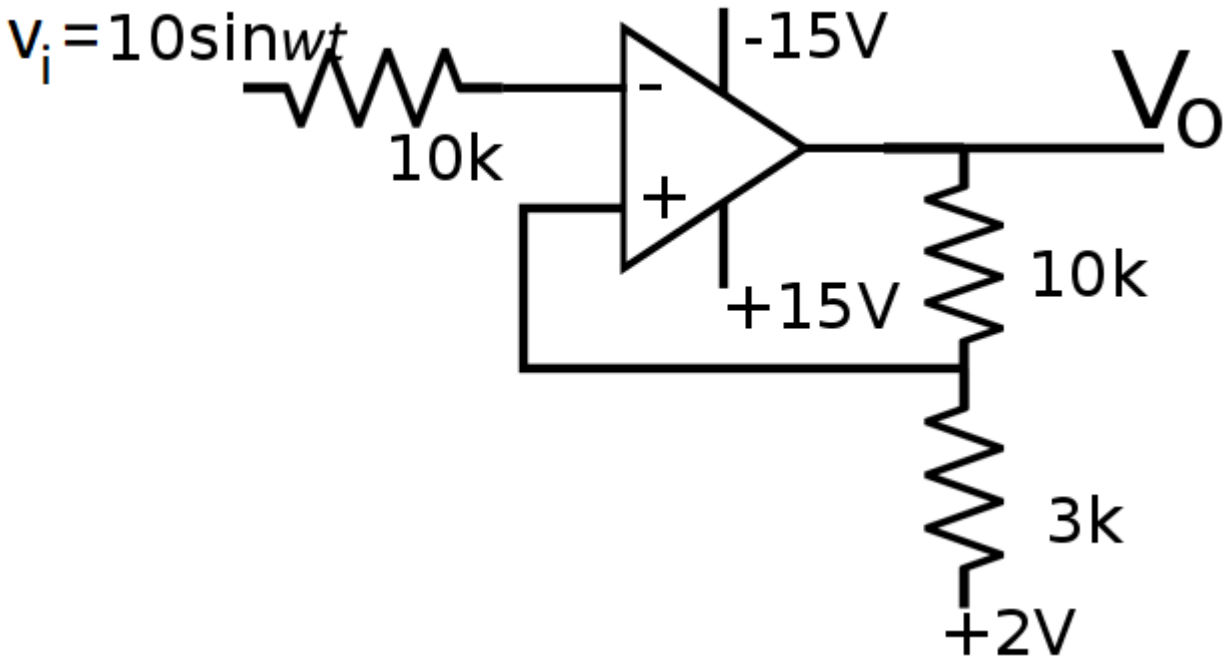
4.
The output voltage of the Schmitt trigger shown in the figure swings between +15V and -15V. Assume that the operational amplifier is ideal. Determine the value of v_i for which the output will change from +15 to -15 V.



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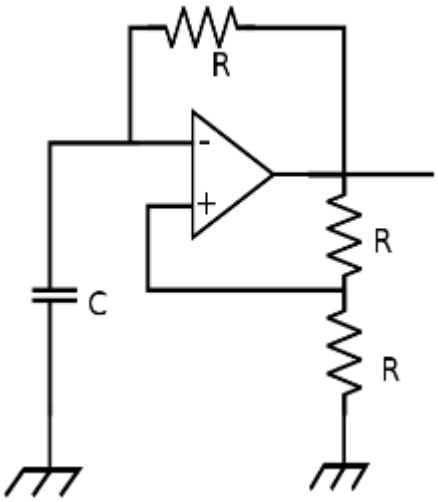
5.
For the astable multivibrator circuit shown in the figure, derive the expression for the time period of oscillation.



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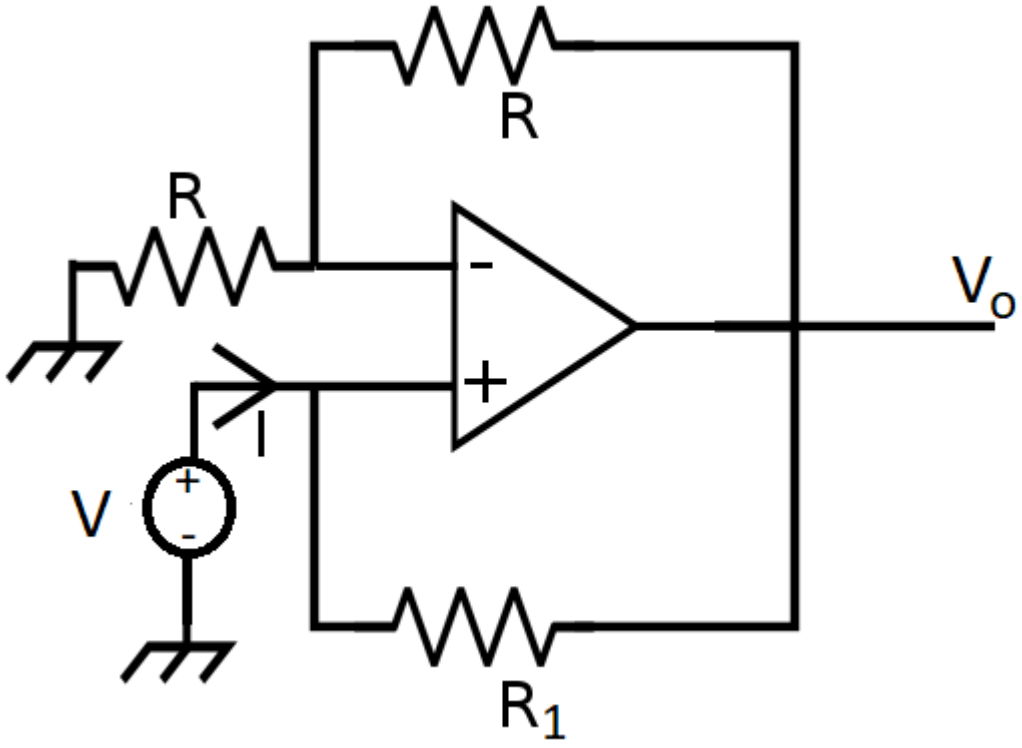
6. Assume that the op-amp is ideal and the output is unsaturated in the figure below.



6.1. Write down the expression for V_o in terms of V.

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6.2. Write down the expression for I in terms of V and R_1

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6.3. Write down the expression for V/I If R_1= R.

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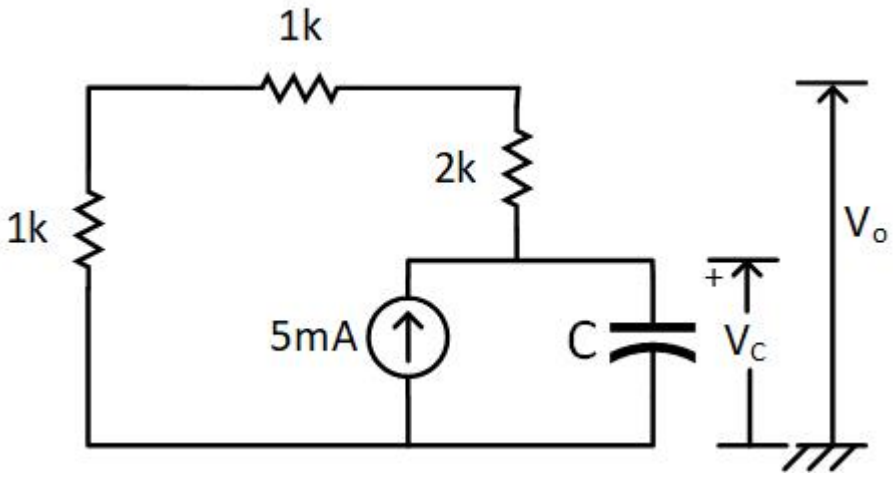
7.

For the circuit shown in fig below, determine the steady state voltage across C and V_0:



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8.
A logic design is required for automatic switching ON & OFF of a motor used for pumping water to a water tank. Two micro-switches are fitted on the water tank to indicate water levels. The first one will close when the water level crosses 50% and the second one when it crosses 80%. It is desired to have water level always between these limits. Write a truth table for the above problem and design a simple logic circuit by which the motor can be switched ON/OFF automatically.

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9.
Let x be an $N \times 1$ binary vector with at most one non-zero value. Using values from $\{0, 1, 2, 3, 4\}$, construct an $M \times N$ matrix $\mathbf{A}$ such that
we can correctly find the vector $\mathbf{x}$ from the product $\mathbf{y} = \mathbf{Ax}$.

9.1. Given that $M = 1$, what is the maximum possible value of N?

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9.2. If $N = 25$, what is the minimum value of M required for us to be able to find $\mathbf{x}$ correctly?

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10.

Using 3 voltage levels for communication, and a switching rate of 1000 throws (switching) per second, a file of size 10 Megabytes can be sent in _____ minutes (correct to one decimal point).

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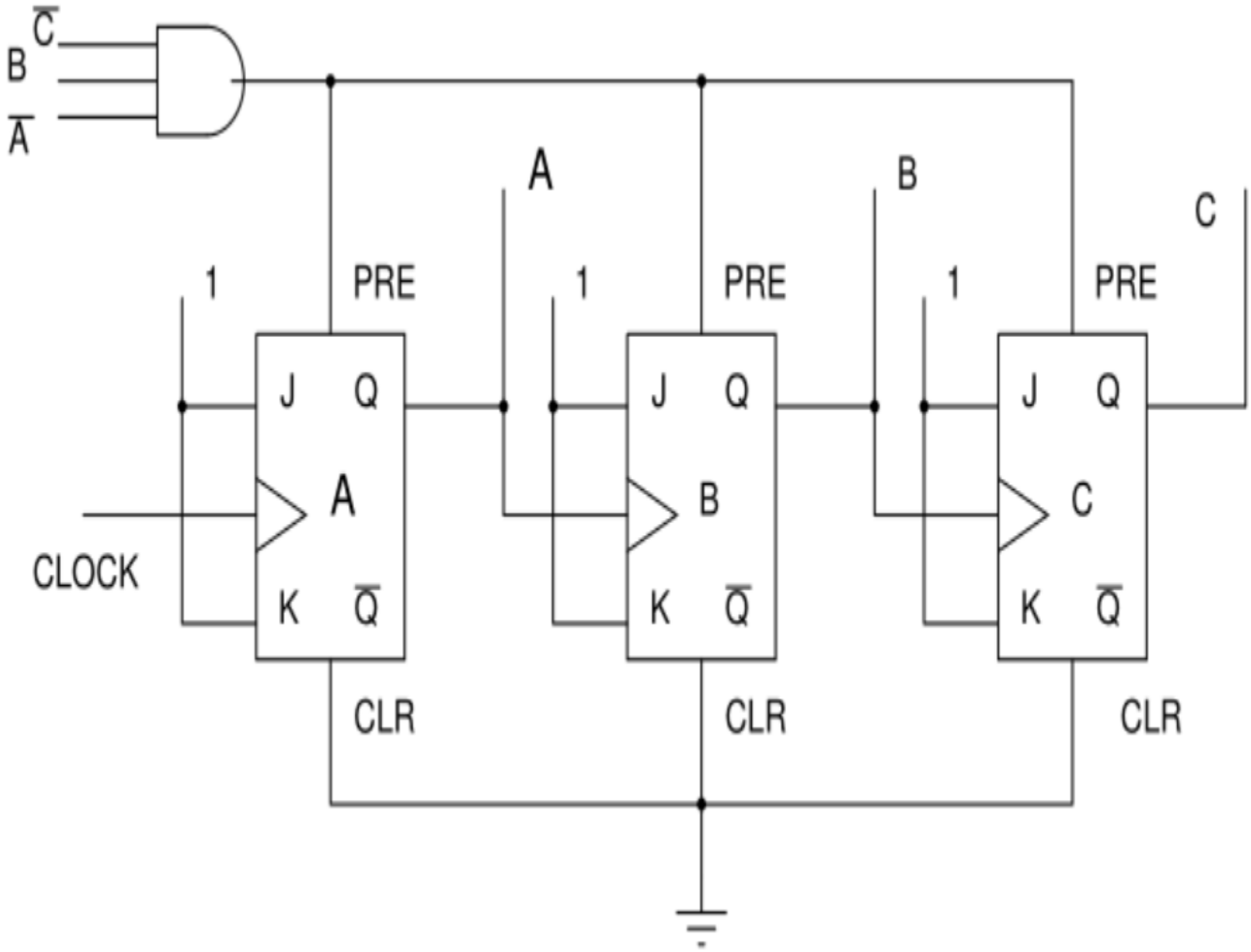
11.

A Ripple counter circuit is shown below which uses +ve edge-triggered JK flip-flops. These flip-flops have active-high asynchronous CLR and PRE inputs (i.e. irrespective of the Clock, when CLR = '1' the flip-flop Q output becomes '0', and when PRE = '1' the flip-flop Q output becomes '1')



11.1.

If the initial state (CBA) is '101', sketch the C, B, and A outputs with respect to the Clock for the present case and the next 8 Clock periods (indicating the correct transitions with respect to the Clock).

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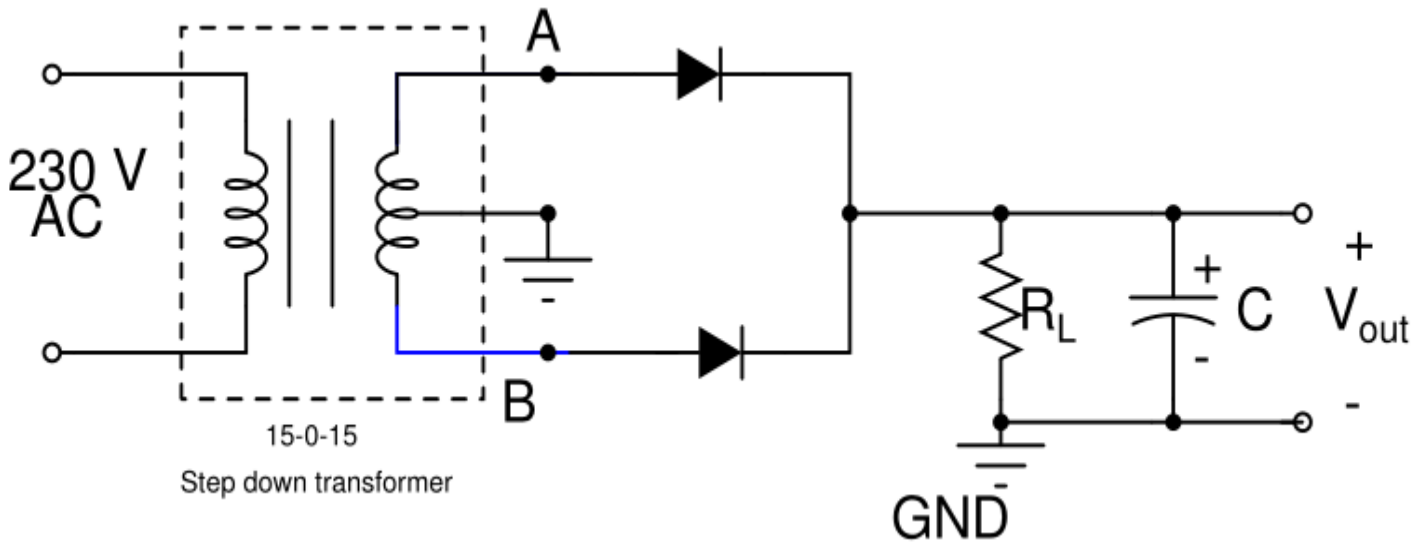
12.
A diode rectifier circuit is shown in the Figure shown below. Transformer input is 230 V rms, and its secondary is 15-0-15 V rms. Sketch the Vout waveform for the three cases given below:



12.1.
For all the three cases, you may neglect the diode drops. Your sketch should indicate the salient voltage levels.

a) R_L removed (or disconnected) but C connected between V_{out} and GND.

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12.2. b) C removed (or disconnected) but R_L connected between V_{out} and GND

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12.3. c) Both R_L and C are connected as shown between V_{out} and GND Marks: 1.68

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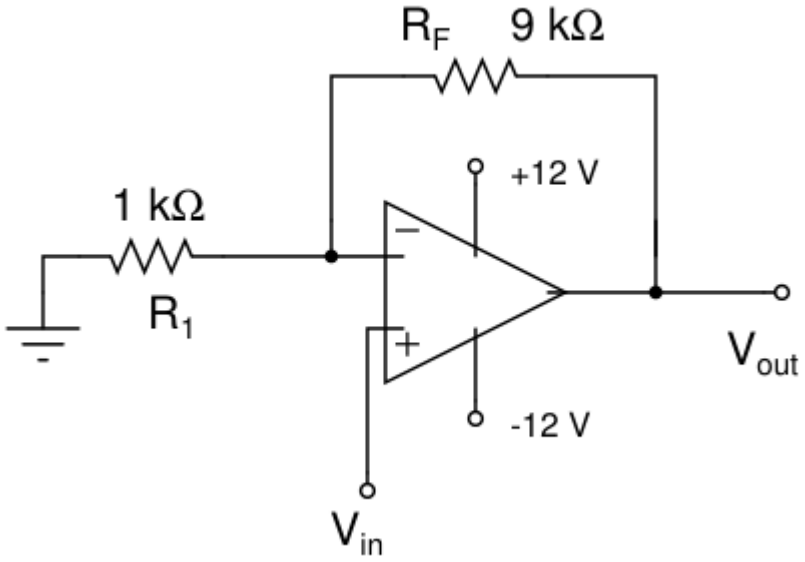
13.
An opamp circuit (using 741 opamp) is shown in the figure below. Sketch the Vin and Vout waveforms for the following cases:



13.1. a) $V_{\text{in}} = 0.75 \sin \omega t V$

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13.2. b) $V_{\text{in}} = 2 \sin \omega t V$

Marks: 2
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