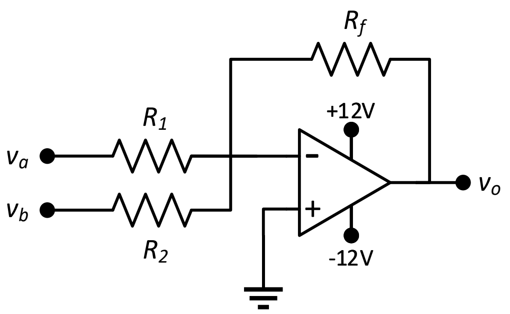
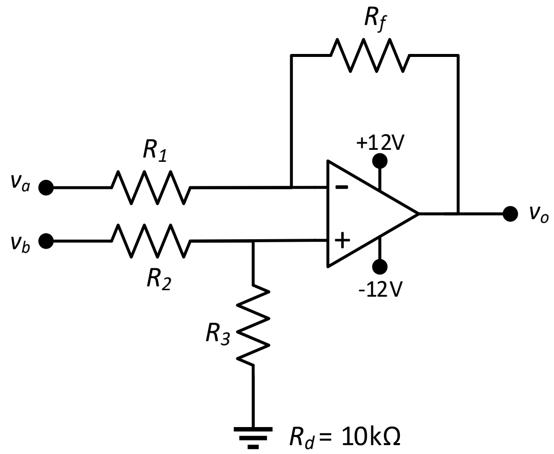
Name:
ID:

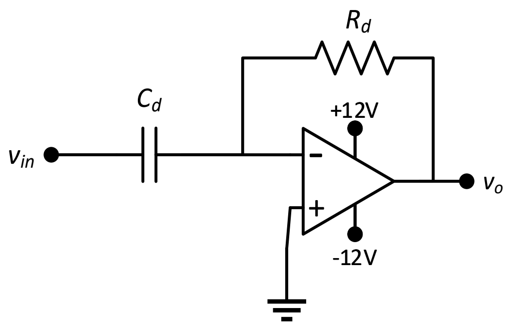
Fall 2025-2026
Duration: 110 Minutes

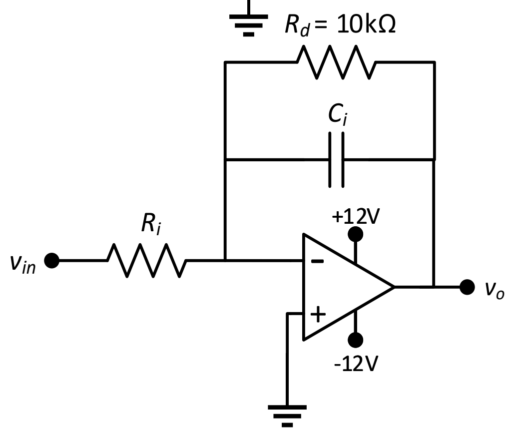
EE 213 Practical Exam
Wednesday Morning

Some Operational Amplifier Topologies

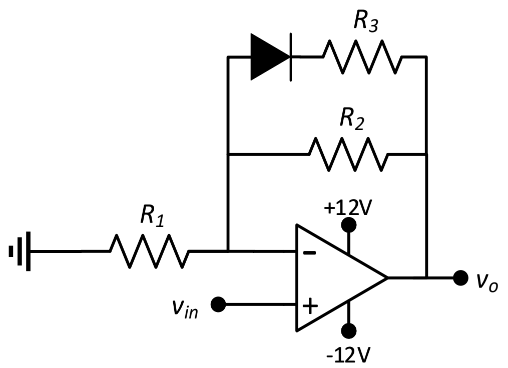


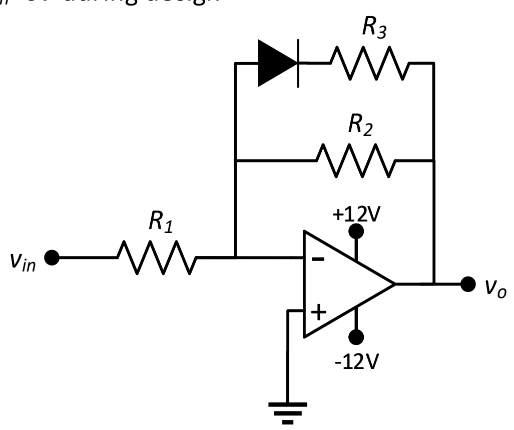






You may assume $V_{D,on}$=0V during design



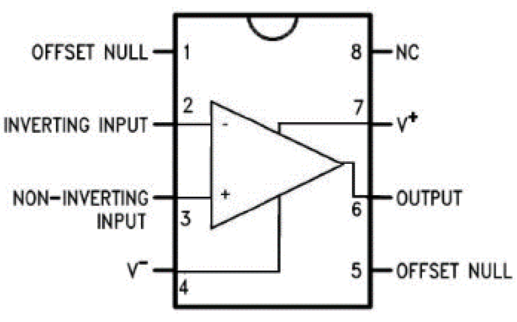


Please read the exam regulations at the back of this page.

Practical Exam Regulations

- **Write your name on all odd numbered pages.**
- Your phones will be collected at the beginning of each session. You are not allowed to take them back until you are told so. Any case failing to comply with this rule will be considered as a cheating attempt.
- Please check the oscilloscope by using "Probe Comp" output; you should see a square wave of 1 kHz frequency and 2.5 V_{p-p} amplitude. Adjust the signal generator to give a square wave and check the output using the oscilloscope. Do not forget to operate the signal generator in High-Z mode (Utility→Output Setup→High-Z).
- Digital multimeters in the laboratory accept probes from both front and rear panels. Please check "Rear/Front" button of the digital multimeters and be sure that the front option is activated.
- Do not forget to make output **ON** for the DC supply and the signal generator whenever you need them. This item may seem redundant to state, but there is a large number of students that forget this during the exam.
- Do not forget to limit the output currents to **100 mA**.
- During the exam, you are required to show all the plots on your exam paper to the assistant while the result is available on the oscilloscope screen. **Figures that are not presented to the assistant during the exam will not be accepted.** If you want to make a change on a plot, call the assistant to show your revised plot.
- The assistants will not answer any of your questions during the exam. The sole exception to this rule is that you can ask the assistant to check your device settings **only for once** so that a minor error will not result in you not performing the task fully.
- All necessary equipment will be given to you in a box. You may ask for components or probes in case of any problem.
- You may ask for changing your table; however, **you need to justify the reason** for your request.

LM741 Pinout Diagram



Components for Design:

5 x 1kΩ, two components for each one of the following set: (1.2 kΩ, 1.5 kΩ, 1.8 kΩ, 2.2 kΩ, 2.7 kΩ, 3.3 kΩ, 3.9 kΩ, 4.7 kΩ, 5.6 kΩ, 6.8 kΩ, 8.2 kΩ, 10 kΩ)

1 µF, 2 x 100 nF

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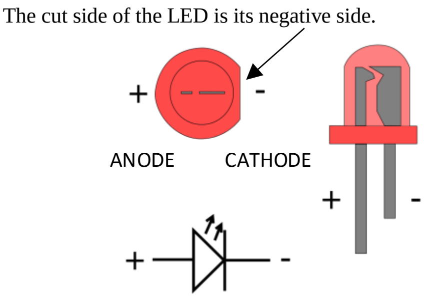
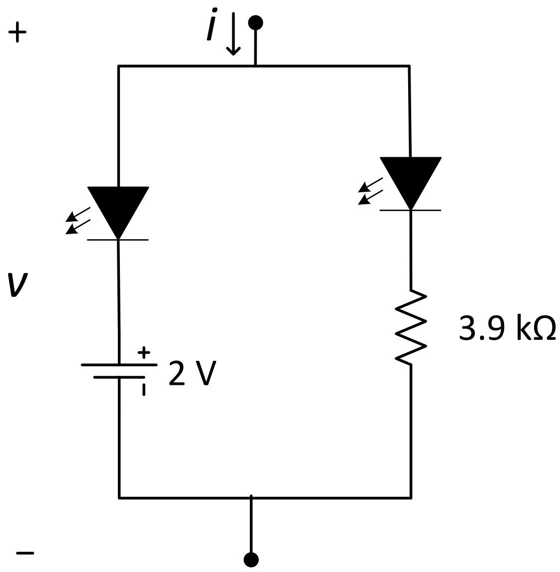
Practical Exam WM Questions

1. Find the *i*-*v* characteristics of the nonlinear device shown below using DSO and function generator (whose frequency is set to 30 Hz). Give the circuit configuration and show the probe connections and DSO settings. Clearly explain the method you used. Plot the result you obtained giving **all the details**. If you **can't** find the *i*-*v* characteristics experimentally, you may plot the theoretical results you expected.

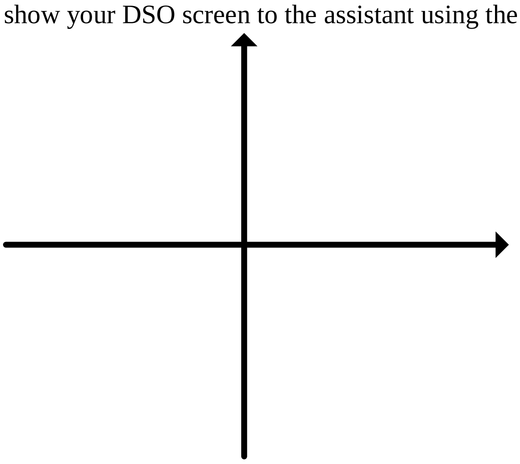




Circuit Configuration & Explanation:

$Vin(t) = A * sin(wt)$	
$A =$	$w =$

Results: (Ideally, give your experimental results with theoretical justifications. Otherwise, for theoretical result, assume that the diode opening voltage is 0.6V and the LED opening voltage is 1.6V.) **Do not forget** to show your DSO screen to the assistant using the given channel resolutions.



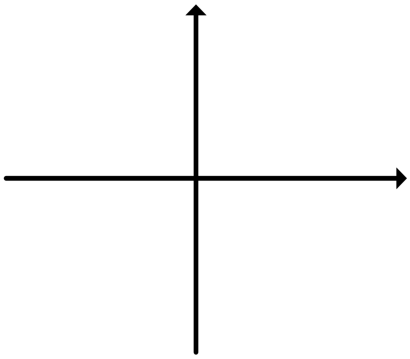
Ch1: 2V/div	**Ch2**: 2V/div

2. In this question, you are required to design an operational amplifier circuit which creates the following relationship between the input and the output.

$$v_{in} = K\frac{dv_{out}}{dt} = K\dot{v}_{out} \equiv v_{out}(t) = \frac{1}{K}\int_{-\infty}^{t} v_{in}(\tau)d\tau$$

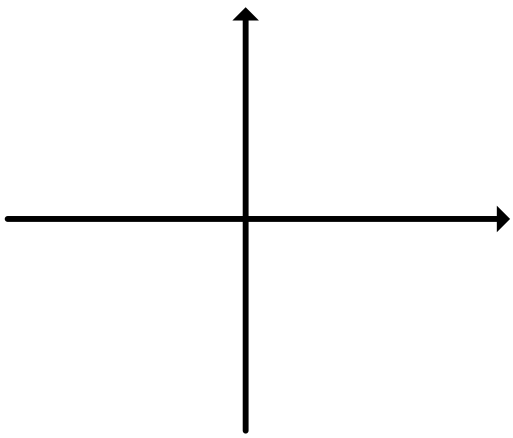
where $K \cong -2.5\,msec$ (range: $-2.75 < K < -2.25$).

a) Draw by hand the v_o and v_{in} vs. t characteristic of this circuit if v_{in} is a square wave with $0V$ DC offset and 50% duty cycle. There is no need to put exact numbers, but your plot should indicate the expected result qualitatively.



b) Draw your circuit configuration below. Calculate the required resistor/capacitor values by analyzing the circuit by assuming that the operational amplifier is in linear region. What is the name of this circuit?

Circuit analysis and design:



Ch v_{in}: 1V/div	**Ch v_{out}**: 0.2V/div	**t**: 500µs/div

c) Obtain and plot $v_o(t)$ and $v_{in}(t)$ **vs.** t, labeling each signal, on the same figure using DSO. Use the space above for your plot and **do not forget** to show the DSO screen to the assistant using the given channel resolutions.

$v_{in}(t)$ is a square wave with $2V_{p-p}$, $0V$ DC offset, 50% duty cycle and 500Hz frequency.

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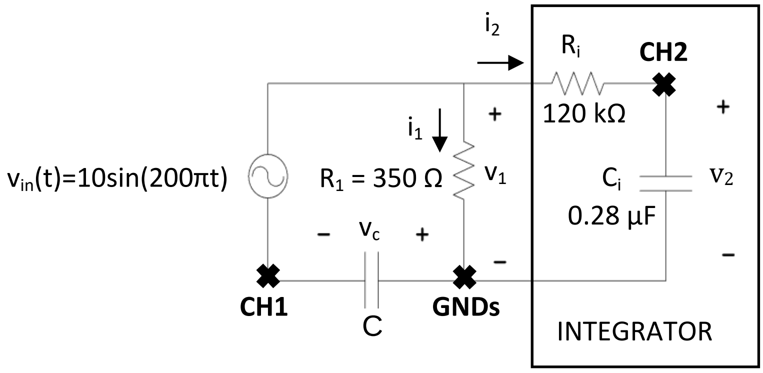
3. (Bonus) You are given MATLAB data files containing Time_s, CH1_data and CH2_data of the circuit shown below.
Using provided data, **plot q-v characteristics of the capacitor C in MATLAB**. Your plot must satisfy the following requirements:

1. **Name** the axes. (Do not forget to include units)
2. Add an appropriate **title** to the plot.
3. Ensure the plot is clear and readable (e.g., use grid lines).



$$v_2(t) \cong \frac{1}{R_i C_i}\int_{-\infty}^{t} v_1(\tau)d\tau$$
$$\cong \frac{R_1}{R_i C_i}\int_{-\infty}^{t} i_1(\tau)d\tau$$
$$\cong \frac{R_1}{R_i C_i} q(t)$$

(Show the assistant the MATLAB figure which includes your plot.)