Op-amp amplifier revision.

1). While trying to use a computer for video conferencing, it is found that the sound level is too weak. An amplifier is needed which will boost the output voltage from the microphone by a factor of about 10. A student is commissioned to construct this amplifier and finds that there are two possible amplifier circuits that could be constructed, an Inverting amplifier and a non-inverting amplifier.

(a) Summarise the two main differences between the two types of amplifier.

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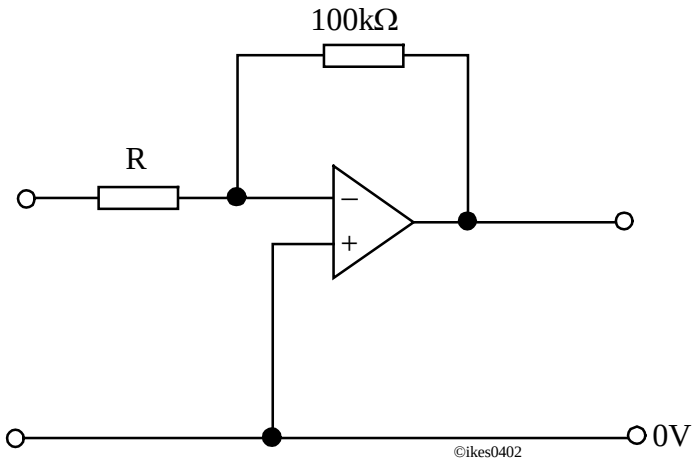
(2)

(b) The circuit diagram for an inverting amplifier is shown below.



(i) Label the input with the word INPUT.

(1)

(ii) Label the output with the word OUTPUT.

(1)

(iii) Label the virtual earth point with the letter P

(1)

(iv) The power supply connections to the op-amp have been omitted. Add them to the circuit diagram above and clearly label them.

(1)

(c) (i) Explain what is meant by the term voltage gain.

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(1)

(ii) State the formula for the voltage gain of the inverting amplifier.

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(2)

(iii) Calculate a value for R so that the output voltage is ten times larger than the input voltage.

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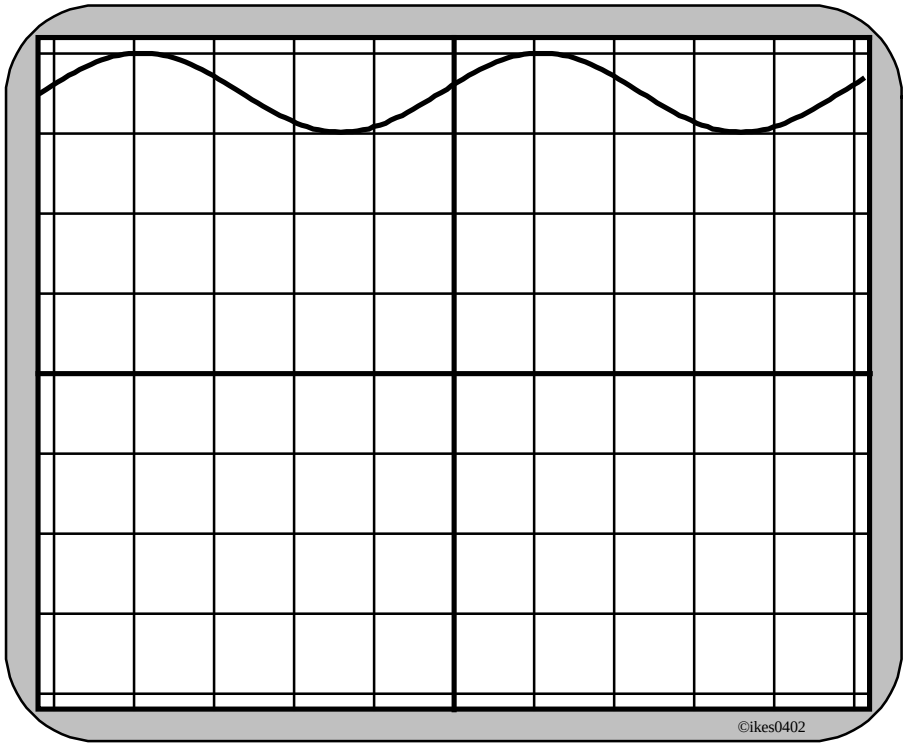
(2)

(d) When constructed the amplifier circuit is connected to a dual 12V power supply. A signal generator provides the input signal and the input and output signals are examined on an oscilloscope. The oscilloscope screen is shown below together with the input signal.



(i) The sensitivity of the channel connected to the input is 1.0V/div.
What is the amplitude of the input signal?

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(1)

(ii) The timebase is set to 200μs/div.
Calculate the frequency of the input signal.

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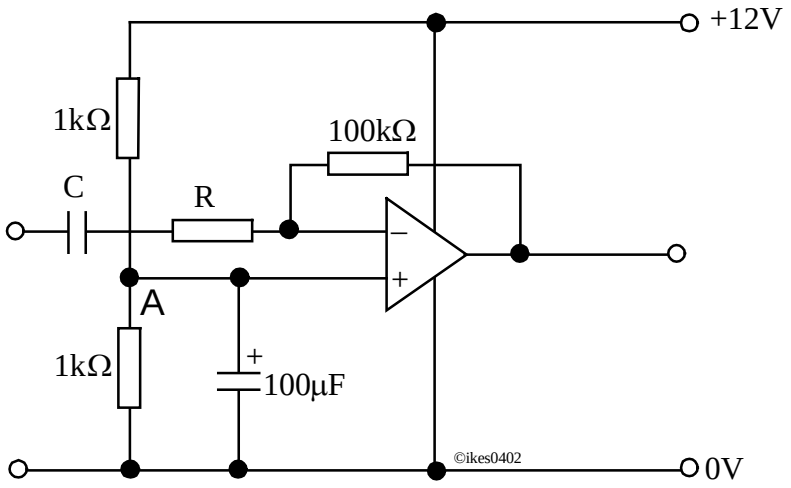
(2)

(iii) If the channel connected to the output has a sensitivity of 2V/div, draw the output waveform onto the oscilloscope diagram.

(3)

(e) Although the amplifier functions correctly, it is difficult to obtain a dual power supply from a computer system. The amplifier circuit was modified, as in the diagram below, to enable it to operate from 12V.



(i) Calculate the voltage at point A

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(1)

(ii) Explain the purpose of capacitor C and suggest a suitable value for it.

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(2)

(iii) Explain the purpose of the 100µF capacitor.

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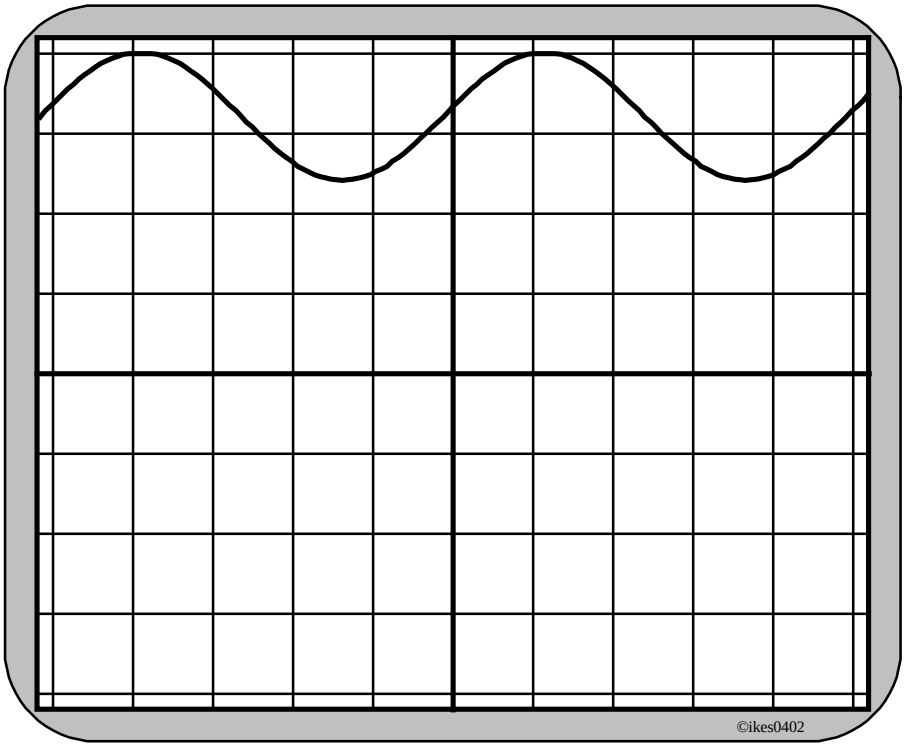
(1)

(f) The amplifier is again tested and this time the input signal is increased to 0.75V amplitude. The sensitivity of the oscilloscope channel is unchanged.

(i) Mark onto the oscilloscope diagram below what the output will now look like.



(3)

(ii) Explain the appearance of the new waveform.

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(2)

(iii) Explain why is the distortion observed in the oscilloscope trace of the output unlikely to be noticed in this application.

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(1)

(g) (i) When used with a high impedance microphone, the output signal is smaller than expected. Explain why this is so.

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(1)

(ii) Explain why a non-inverting amplifier would not suffer from this difficulty.

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(1)

(iii) In the space below draw the circuit diagram of a non-inverting amplifier that uses a 100kΩ feedback resistor and would operate from a single 12V supply. Label the Input and Output.

(iv) State the formula for the voltage gain of a non-inverting amplifier.

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(1)

(v) Calculate the value of the other resistor needed to achieve a voltage gain of 10.

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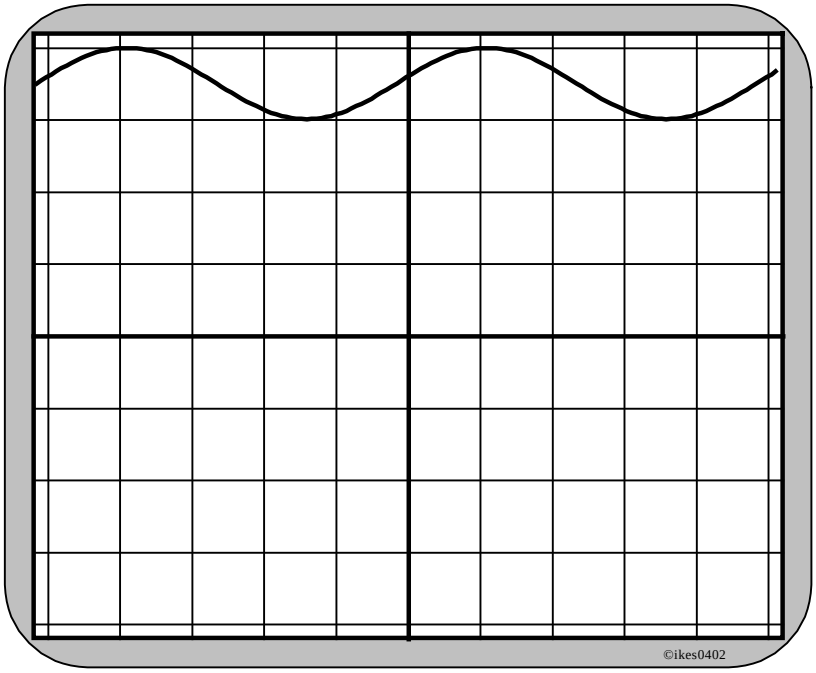
(2)

(h) When constructed the amplifier circuit is connected to a 12V power supply. A signal generator provides the input signal and the input and output signals are examined on an oscilloscope. The oscilloscope screen is shown below together with the input signal.
The sensitivity of the channel connected to the input is 1.0V/div.
The sensitivity of the channel connected to the output is 2.0V/div.
Draw the output waveform onto the oscilloscope diagram below.

(2)



(i) (i) Explain what is meant by the bandwidth of an amplifier.

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(2)

(ii) Explain what is meant by the gain bandwidth product of an op-amp.

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(2)

(iii) If an op-amp has a gain bandwidth product of 10^6, what will be the approximate bandwidth of an amplifier with a voltage gain of:-

(A) 1000

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(B) 10

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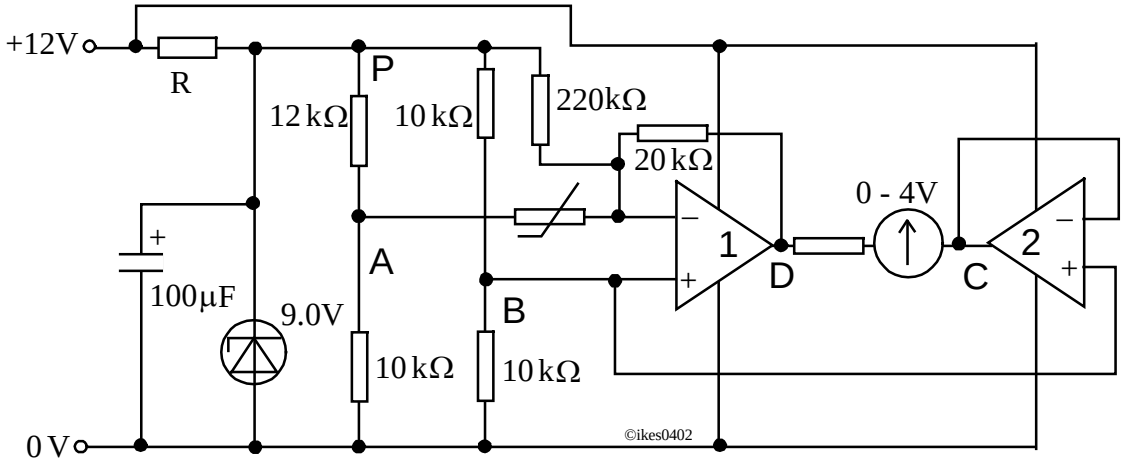
(3)

2). The circuit diagram of a limited range thermometer is shown below.



(a) Mark onto the circuit diagram above the following sub-systems:

(i) a voltage regulator sub-system,
(ii) an input sub-system,
(iii) a voltage divider sub system,
(iv) an output sub-system,
(v) an summing amplifier sub-system,
(vi) a buffer subsystem.

(6)

(b) (i) Explain why the voltage at point P is 9.0V.

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(1)

(ii) The 9V zener diode has a maximum power rating of 400mW. Calculate the maximum current that can pass through this diode.

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(2)

(iii) Calculate the minimum value for resistor R.

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(2)

(iv) Explain what value resistor you would choose from the E24 series.

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(2)

(v) Calculate a suitable power rating for this resistor.

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(2)

(c) Using the graph of the characteristic of the thermistor, state the resistance of the thermistor at the following temperatures:

(i) 10ºC .....

(ii) 20ºC .....

(iii) 25ºC .....

(iv) 40ºC .....

(v) 50ºC .....

(5)

(d) (i) Calculate the voltage at point B.

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(2)

(ii) Calculate the voltage at point A

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(2)

(iii) State, with a reason, the voltage at point C.

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(2)

(iv) State and explain the function of op-amp 2

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(2)

(v) If the meter reads zero volts, state, with a reason, the voltage at D.

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(2)

(e) (i) State the formula for the output voltage of a summing amplifier.

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(1)

(ii) What is the resistance of the thermistor at 20°C?

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(1)

(iii) Calculate the difference in voltage between points A and B.

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(1)

(iv) Calculate the output voltage of the summing amplifier when the thermistor is at a temperature of 20°C.

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(3)

(v) Calculate value of resistance would produce an output voltage of 4V.

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(3)

(vi) State, with a reason, the temperature range that the meter will indicate.

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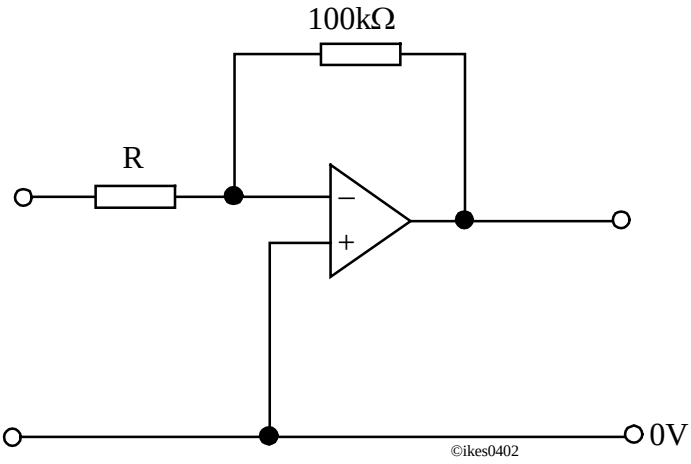
(2)


100kΩ
R
0V
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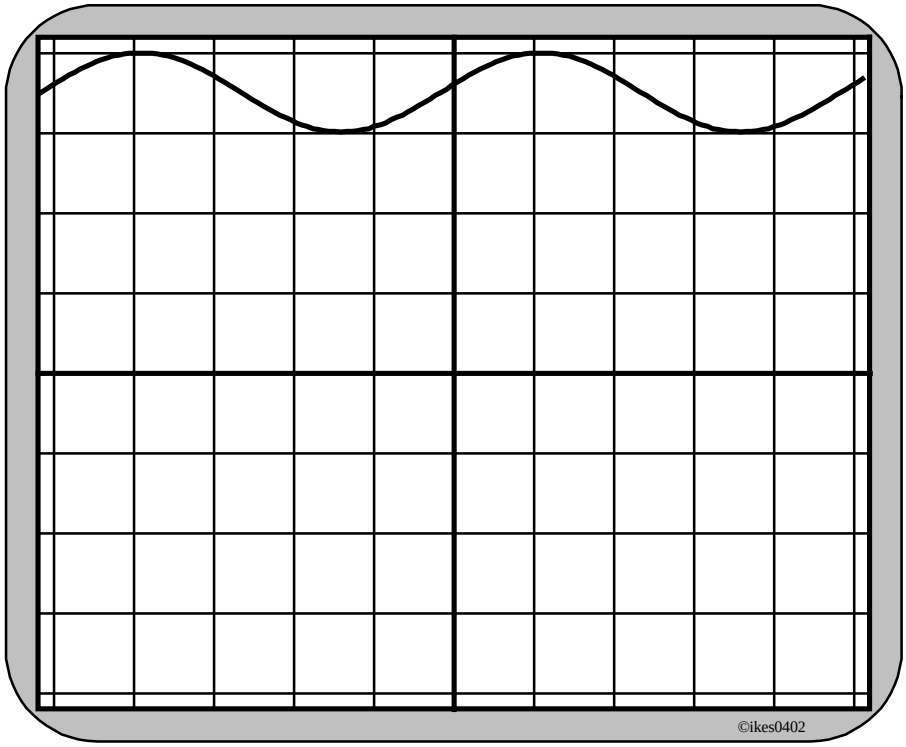
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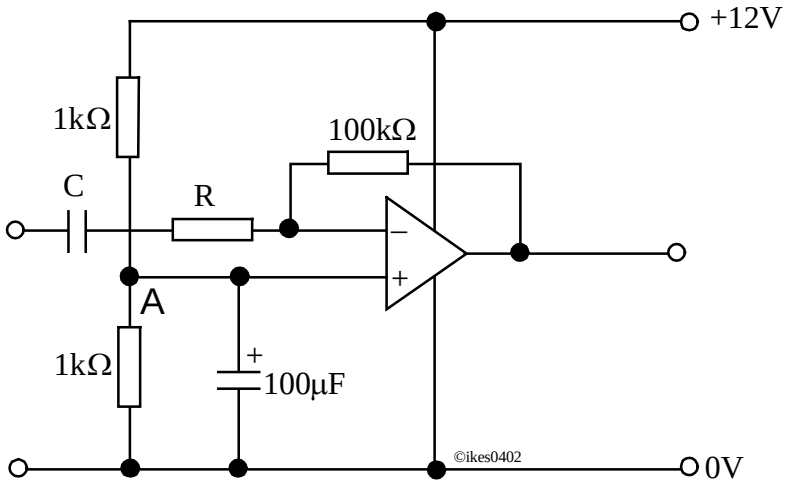
+12V
1kΩ
100kΩ
C
R
A
1kΩ
100µF
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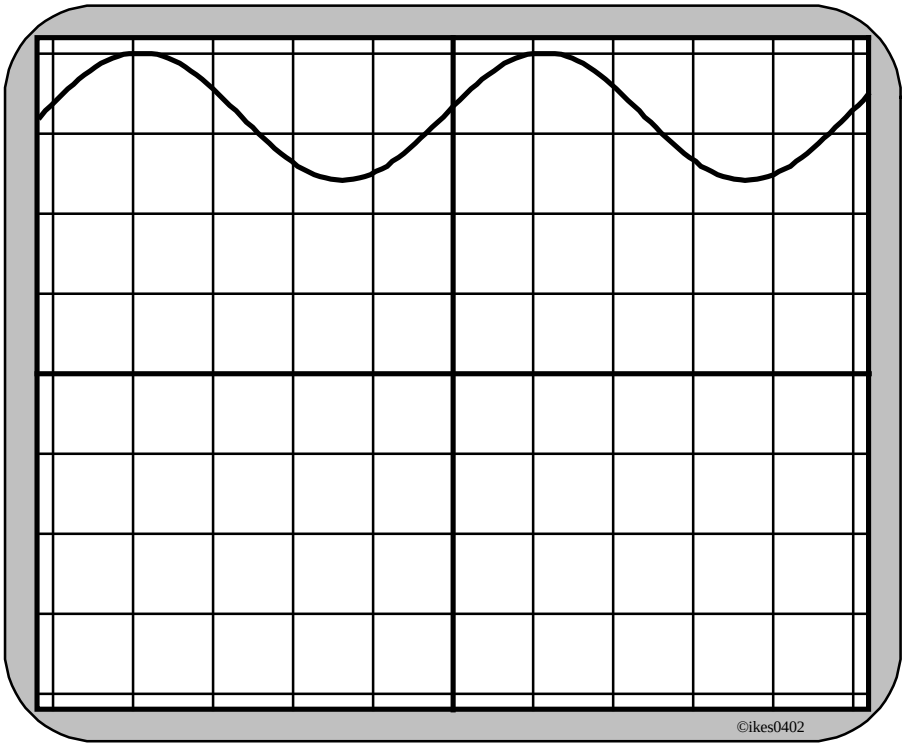
0V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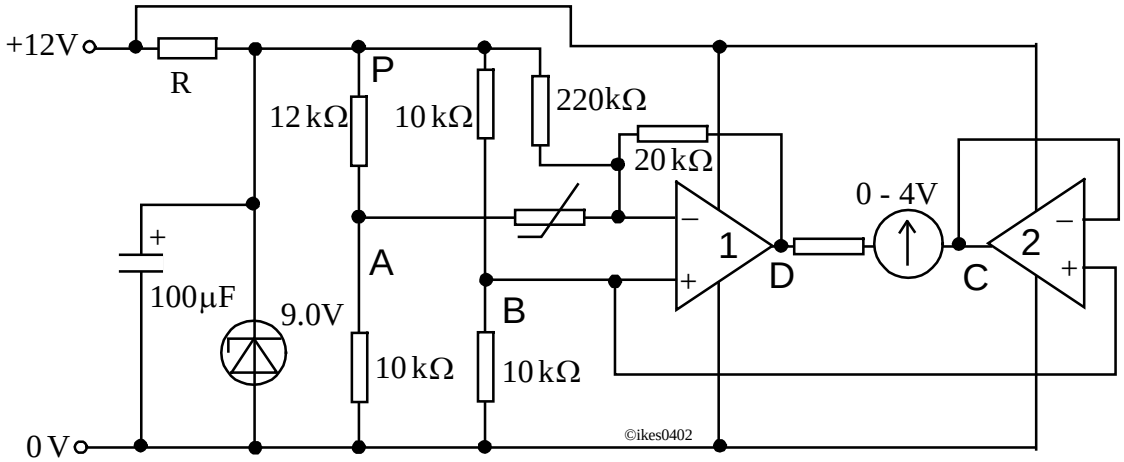
+12V
R
P
12 kΩ
10 kΩ
220kΩ
20 kΩ
0 - 4V
+
100µF
9.0V
A
B
1
2
D
C
10 kΩ
10 kΩ
0 V
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