Higher
-o-O-o-
Analogue
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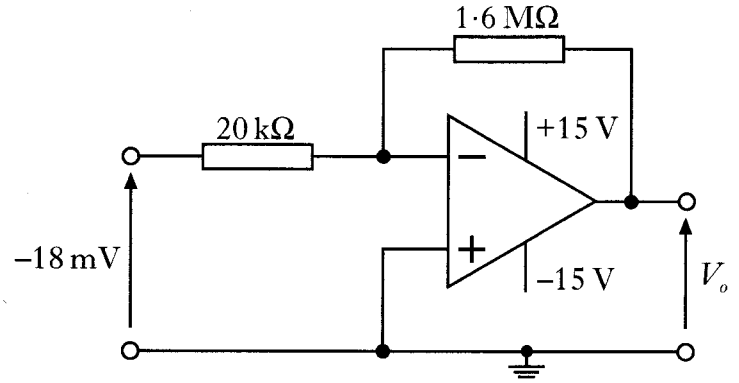
Past Paper questions
2000 - 2010

2001 Q26.

(a) An op-amp is connected in a circuit as shown below.

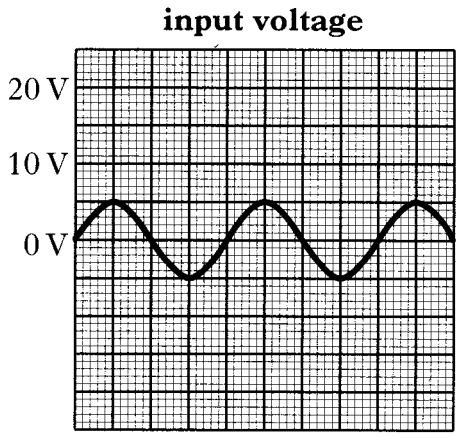


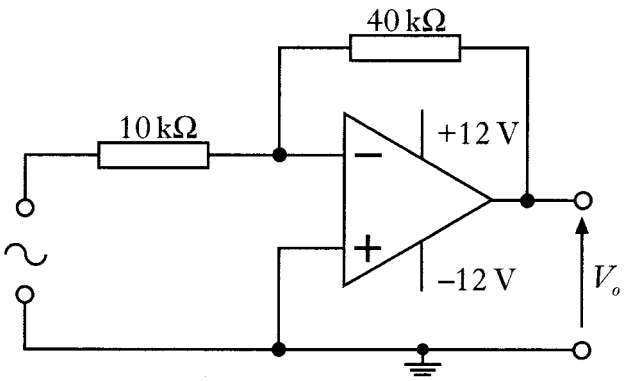
(i) In which mode is the op-amp operating?

(ii) A voltage of -18 mV is connected to the input.
Calculate the output voltage V_o.

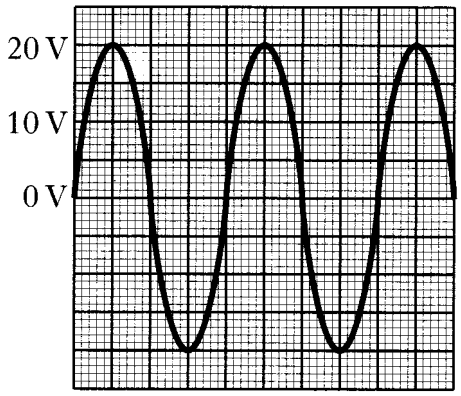
(iii) The supply voltage is now reduced from ±15 V to ±12 V.
State any effect this change has on the output voltage. You must justify your answer.

(b) A student connects an op-amp as shown in the following diagram.
An alternating voltage of peak value 5.0 V is connected to the input as shown.





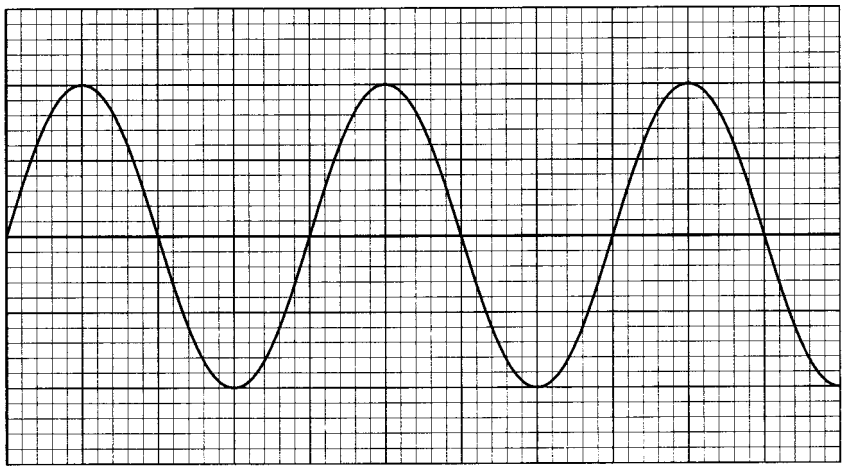
The sketch below shows the student's attempt to draw the corresponding output voltage.



State the **two** mistakes in the student's sketch.

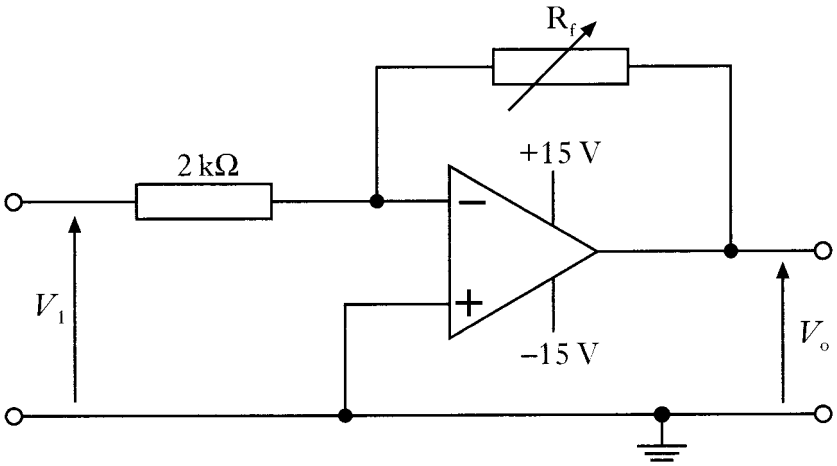
2002 Q26.

An alternating voltage signal displayed on an oscilloscope screen is shown below.
The peak voltage is 6.0 V and the time base setting is 2 ms/cm.



(a) Calculate the frequency of the signal.

(b) This alternating voltage is used as the input voltage V_1 for the operational amplifier circuit shown below. R_f is a variable resistor.



(i) In what mode is the operational amplifier operating?

(ii) The variable resistor R_f is set at 3.0 kΩ.

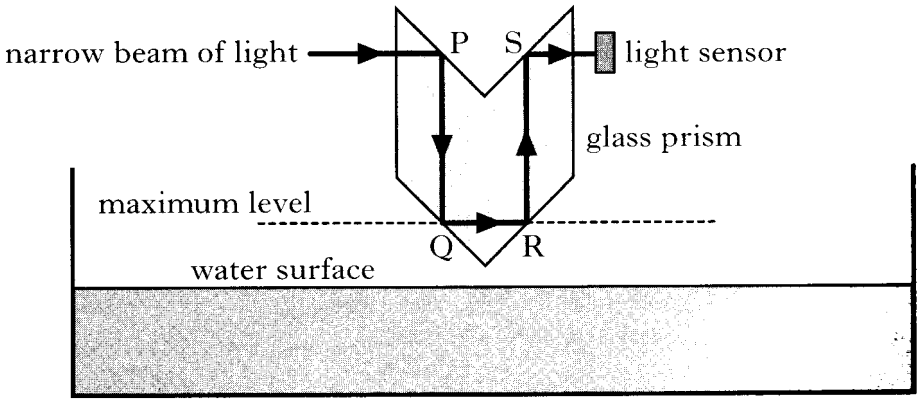
(A) On square ruled paper, sketch a graph of the output voltage V_o. Numerical values must be shown.

(B) Calculate the **r.m.s.** value of the output voltage V_o.

(iii) The resistance of resistor R_f is gradually increased from 3 kΩ to 8 kΩ. Describe what happens to the output voltage V_o during this time.

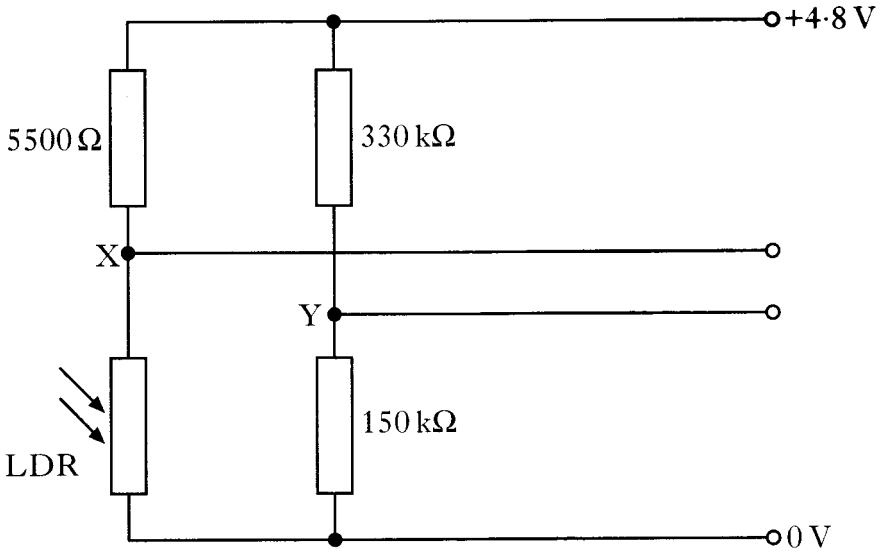
2003 Q26.

A washing machine is filled with water, emptied and refilled several times during a wash cycle.
A water level detector is used to ensure the water does not overflow.
One design of water level detector uses a specially shaped glass prism, as shown below.



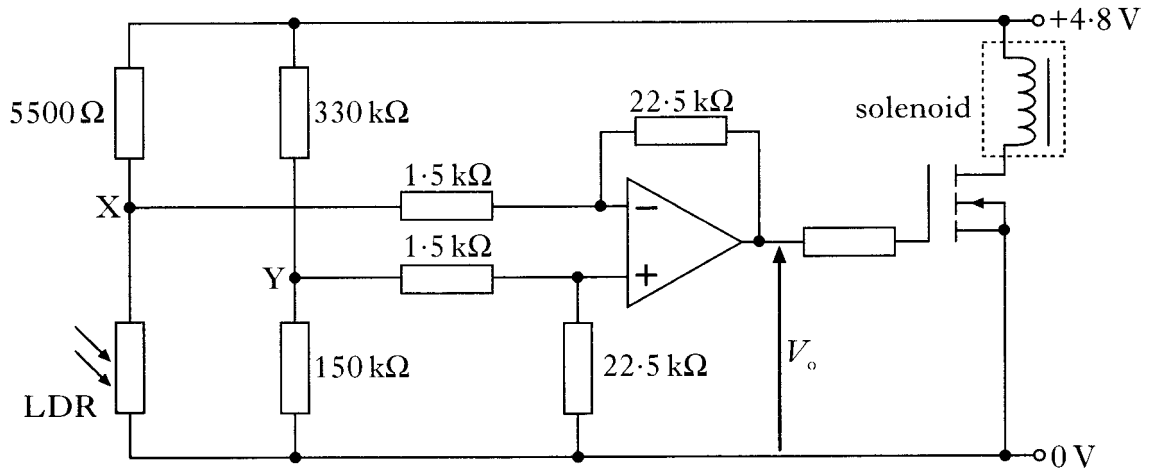
When the water in the machine is below the maximum level indicated in the diagram, the light sensor is illuminated by the narrow beam of light.

(a) The light sensor consists of an LDR connected in a Wheatstone bridge circuit with values of resistance as shown.



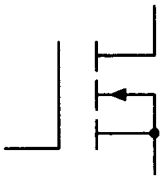
When the water in the machine is at the maximum level, the bridge is balanced.
Calculate the resistance of the LDR when the bridge is balanced.

(b) Points X and Y of the Wheatstone bridge are connected to the inputs of an op-amp circuit as shown.



The potential at Y is 1.50V. When the washing machine is filling with water, the narrow beam of light illuminates the LDR, the bridge is unbalanced and the potential at X is 1.28 V.

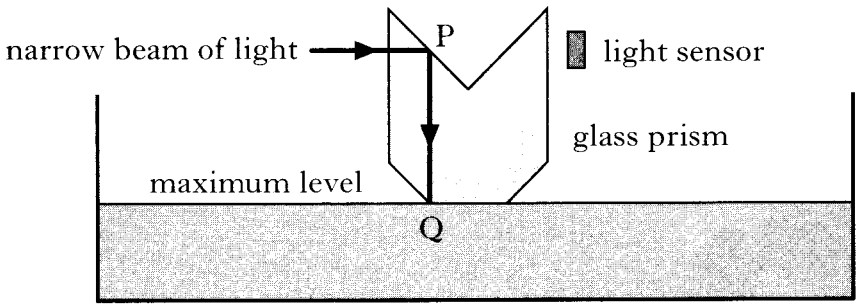
(i) Name the component in the circuit which has the following symbol.



(ii) Calculate the output voltage V_o of the op-amp when the LDR is illuminated.

(iii) When there is a current in the solenoid, it holds a valve open and water flows into the washing machine.
When the water reaches the maximum level, the valve closes.
Explain how the circuit causes the valve to close when the water reaches the maximum level.

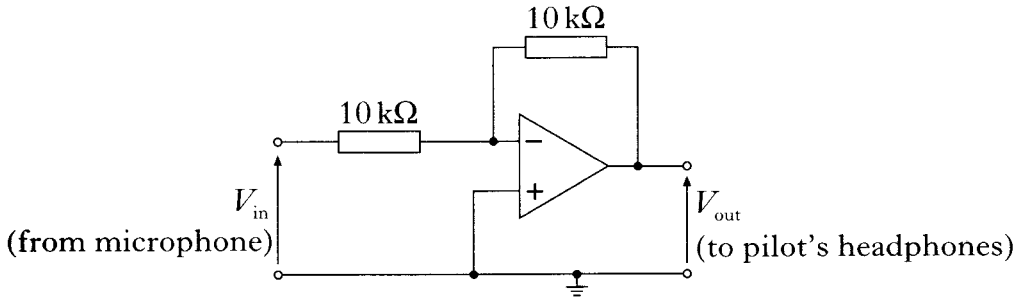
(c) When the water is at the maximum level, the narrow beam of light no longer illuminates the light sensor, because light leaves the prism at Q.



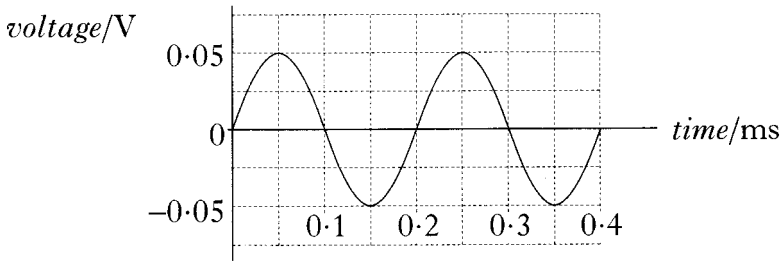
Explain why the light leaves the prism at Q.

2003 Q28. (part)

(b) A microphone is placed inside the cockpit of a jet aircraft.
The microphone is connected to the input terminals of the op-amp circuit shown below.



A noise in the cockpit produces the following signal from the microphone.

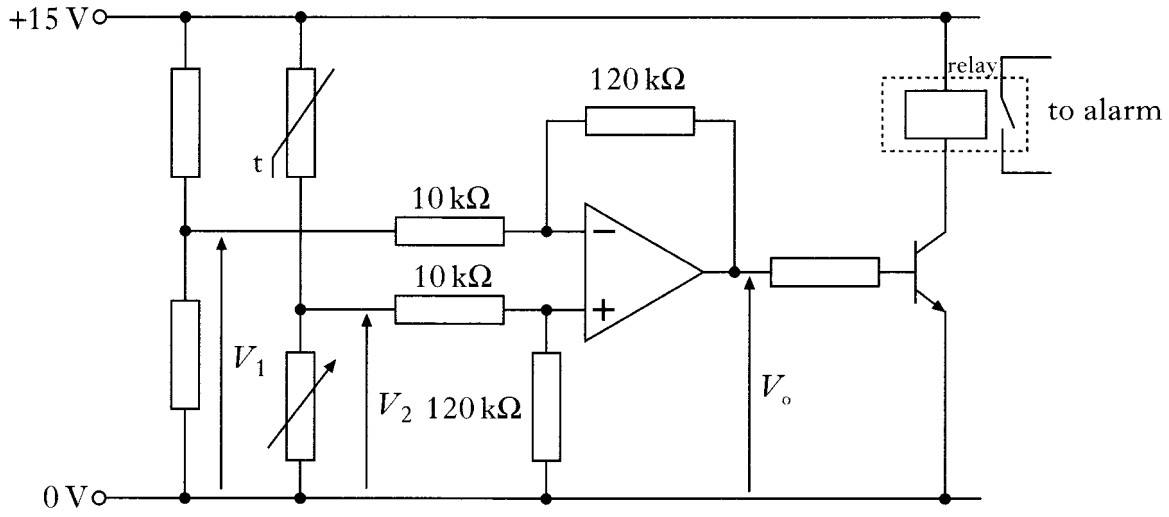


(i) Sketch a graph of the corresponding output voltage V_{out} against time.
Values are required on both axes.

(ii) The output from the op-amp is connected to the pilot's headphones.
Explain why the sound produced by the headphones **reduces** the noise level heard by the pilot.

2004 Q26.

The circuit shown is designed for an alarm system.

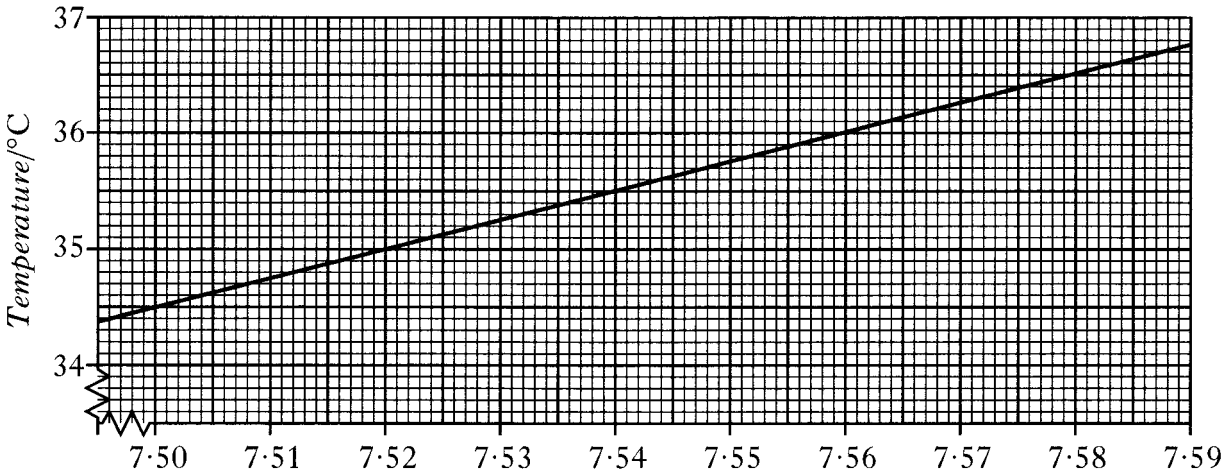


Voltage V_1 is 7.50V. When the temperature increases, the resistance of the thermistor decreases.

(a) At a temperature of 35°C, voltage V_2 is 7.52 V.
Calculate the output voltage V_o at this temperature.

(b) When the temperature rises, V_o increases and the alarm switches on.
Explain how the circuit operates to switch on the alarm.

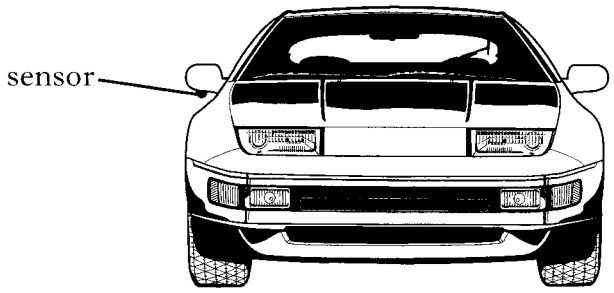
(c) The alarm is on when V_o is greater than or equal to 0.72 V.
The graph of the temperature against voltage V_2 is shown.



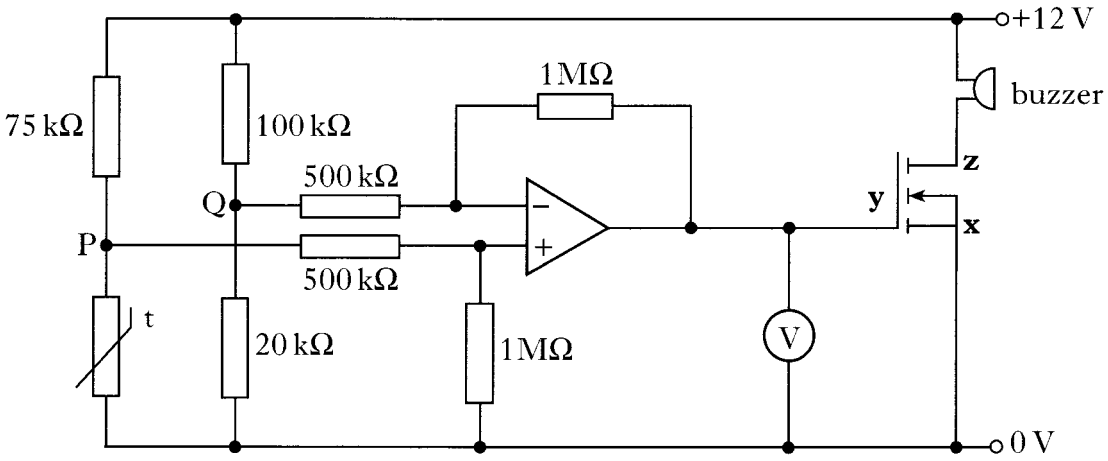
Using information from the graph, determine the minimum temperature at which the alarm switches on.

2005 Q27.

A car is fitted with an alarm which sounds a buzzer when the outside temperature falls below 3°C. The sensor is a thermistor located under the mirror on the side of the car.



The thermistor forms part of the circuit shown.



(a) What names are given to the terminals labelled **x**, y and **z** on the symbol for the MOSFET? Clearly indicate which name goes with which letter.

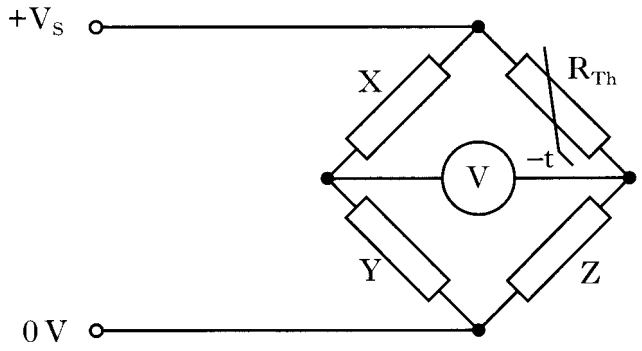
(b) The buzzer sounds when the reading on the voltmeter is greater than or equal to +2.0 V.

(i) Calculate the minimum potential difference required between points P and Q to sound the buzzer.

(ii) Calculate the resistance of the thermistor when the reading on the voltmeter is +2.0 V.

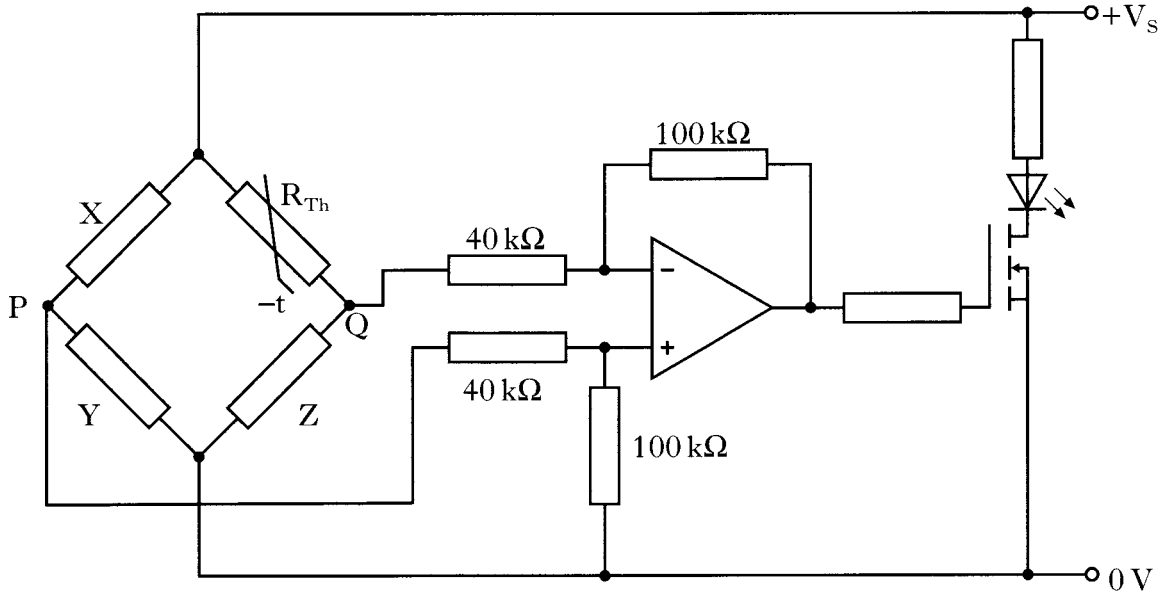
2007 Q27.

A Wheatstone bridge is used to measure the resistance of a thermistor as its temperature changes.



(a) The bridge is balanced when X = 2.2 kΩ, Y = 5.0 kΩ and Z = 750 Ω .
Calculate the resistance of the thermistor, R_{Th}, when the bridge is balanced.

(b) A student uses this bridge in a circuit to light an LED when the temperature in a greenhouse falls below a certain level.



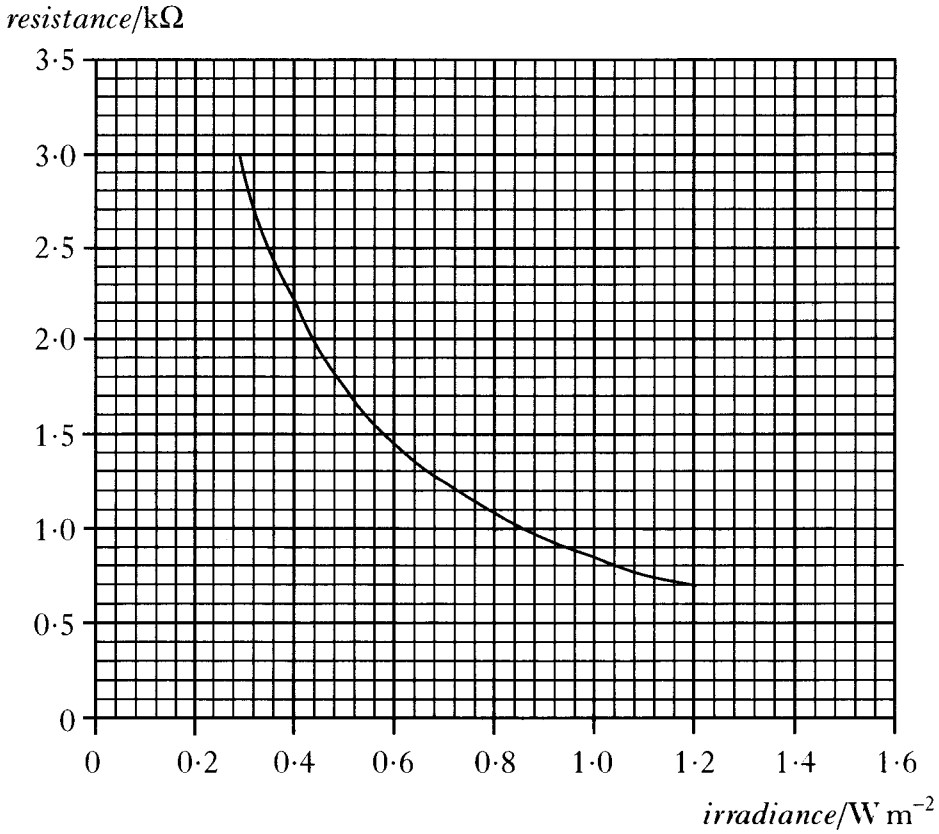
(i) In which mode is the op-amp being used?

(ii) As the temperature of the thermistor falls, its resistance increases.
Explain how this whole circuit operates to cause the LED to light when the temperature falls.

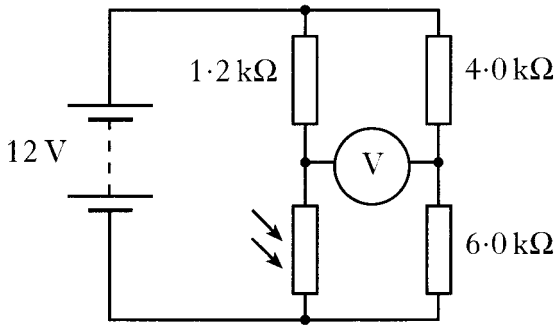
(iii) At a certain temperature the output voltage of the op-amp is 3.0V.
Calculate the potential difference between P and Q at this temperature.

2008 Q26.

The graph shows how the resistance of an LDR changes with the irradiance of light incident on it.

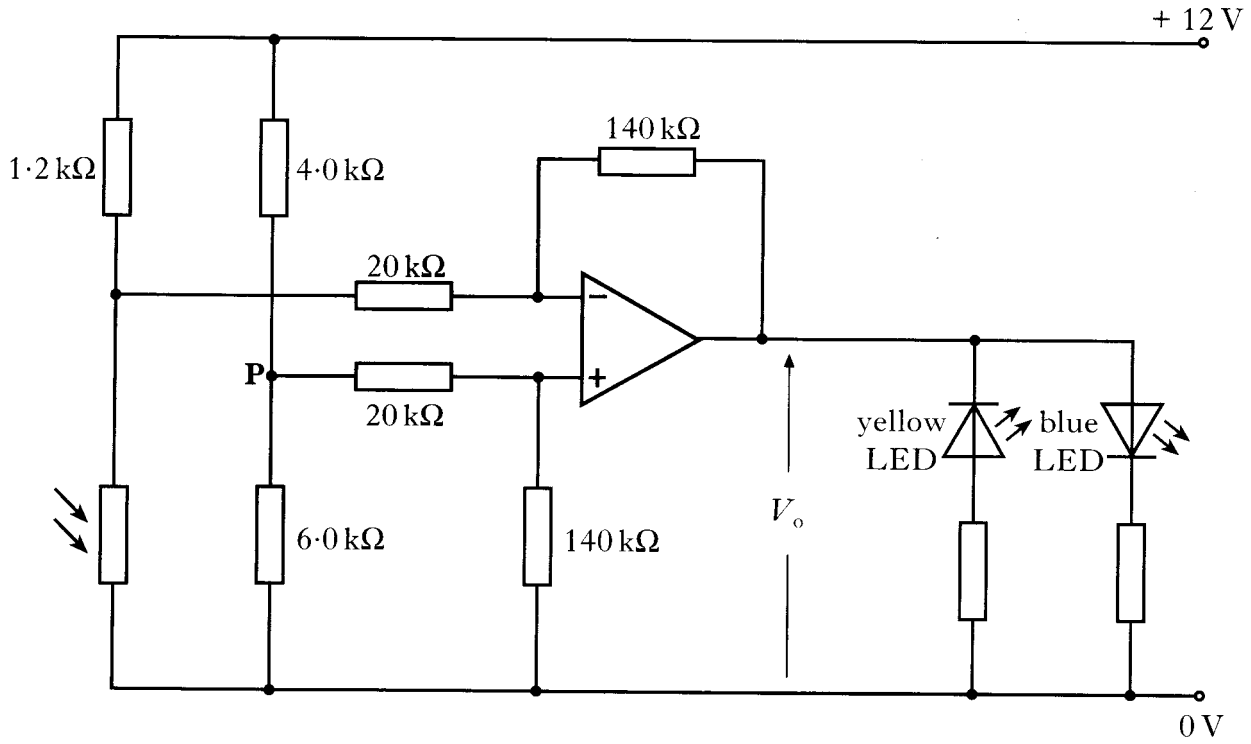


(a) The LDR is connected in the following bridge circuit.



Determine the value of irradiance at which the bridge is balanced.
Show clearly how you arrive at your answer.

(b) The LDR is now mounted on the outside of a car to monitor light level.
It forms part of a circuit which provides an indication for the driver to switch on the headlamps.
The circuit is shown below.



The LEDs inside the car indicate whether the headlamps should be on or off.

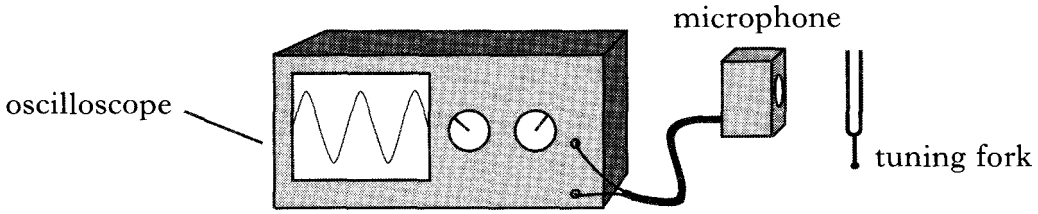
(i) At a particular value of irradiance the resistance of the LDR is 2.0 kΩ.
Show that the potential difference across the LDR in the circuit is 7.5 V

(ii) The potential at point P in the circuit is 7.2 V
Calculate the output voltage, V_o of the op-amp at this light level.

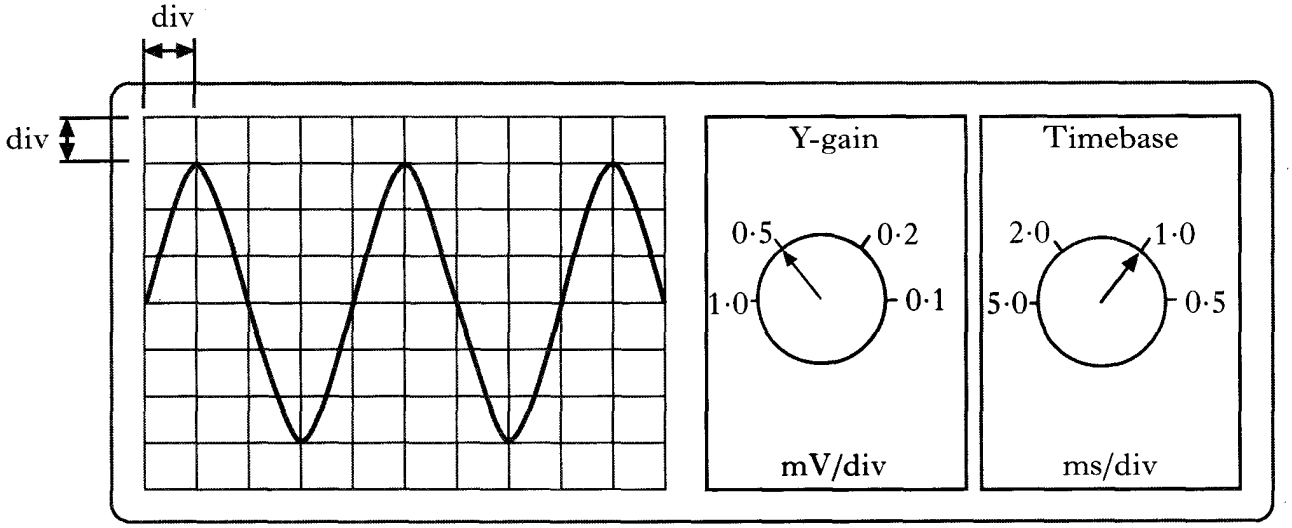
(iii) Which LED(s) is/are lit at this value of output voltage?
Justify your answer.

2009 Q25.

(a) A microphone is connected to the input terminals of an oscilloscope.
A tuning fork is made to vibrate and held close to the microphone as shown.



The following diagram shows the trace obtained and the settings on the oscilloscope.

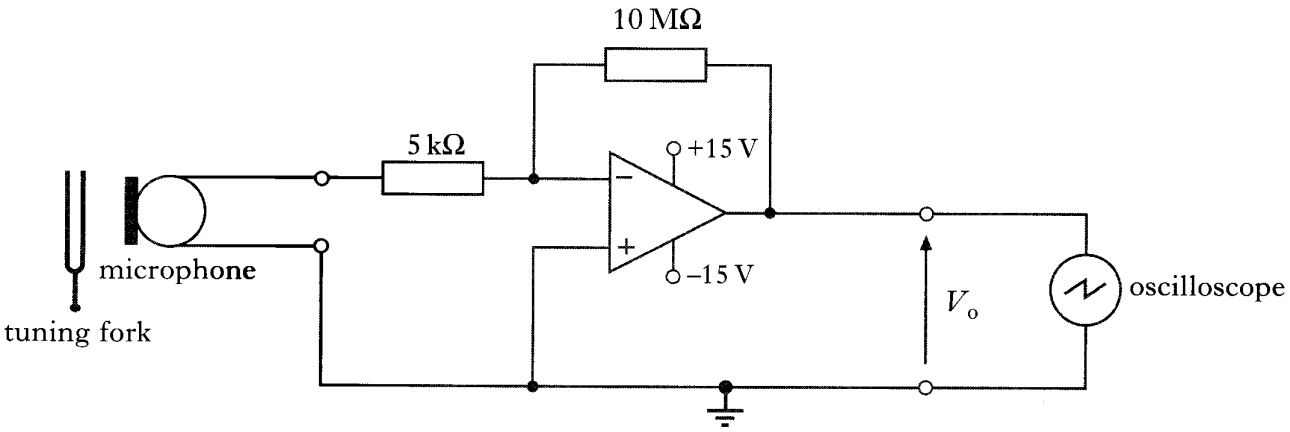


Calculate:

(i) the peak voltage of the signal;

(ii) the frequency of the signal.

(b) To amplify the signal from the microphone, it is connected to an op-amp circuit.
The oscilloscope is now connected to the output of the amplifier as shown.



The settings of the oscilloscope are adjusted to show a trace of the amplified signal.

(i) In which mode is this op-amp being used?

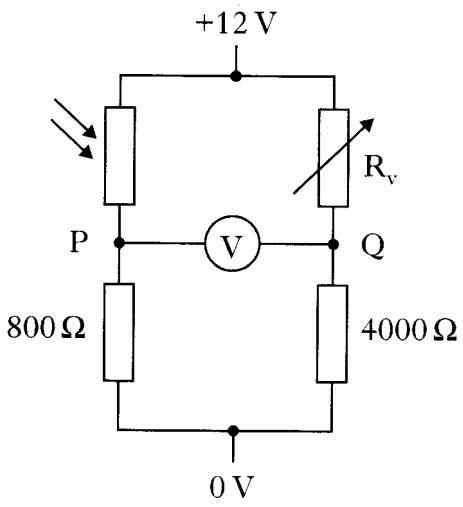
(ii) The peak voltage from the microphone is now 6.2 mV.
Calculate the **r.m.s.** value of the output voltage, V_o of the op-amp.

(iii) With the same input signal and settings on the oscilloscope, the supply voltage to the op-amp is now reduced from ± 15 V to ± 9 V.
What effect does this change have on the trace on the oscilloscope?
Justify your answer.

2010 Q25.

The headlights on a truck are switched on automatically when a light sensor detects the light level falling below a certain value.

The light sensor consists of an LDR connected in a Wheatstone bridge as shown.

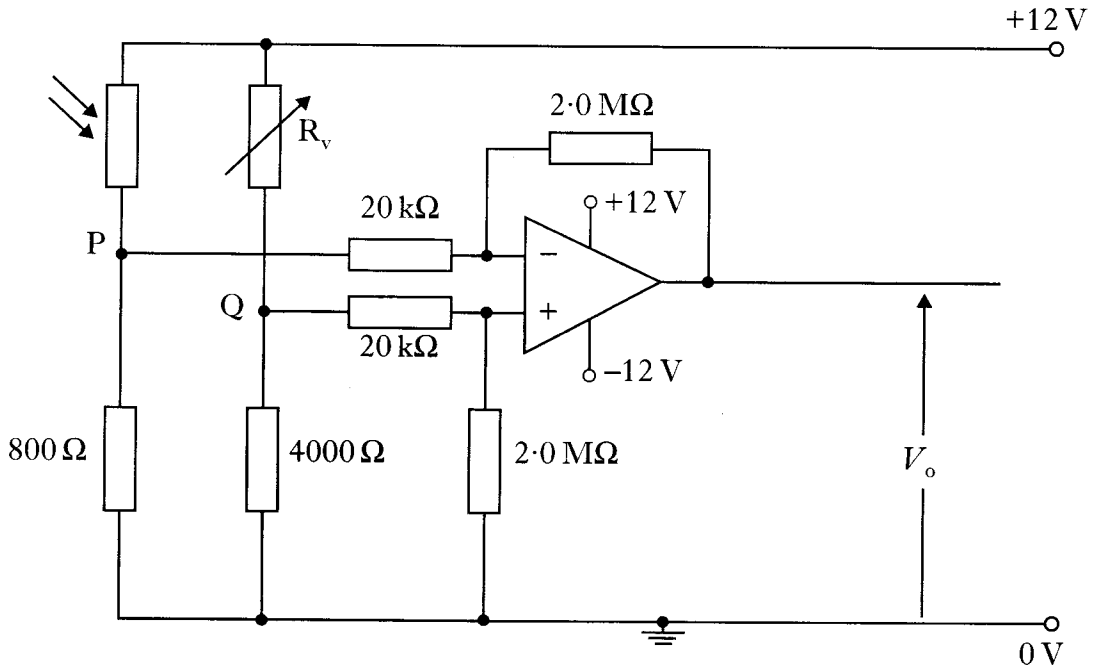


(a) The variable resistor, R_v, is set at 6000 Ω.

(i) Calculate the resistance of the LDR when the bridge is balanced.

(ii) As the light level decreases, the resistance of the LDR increases.
Calculate the reading on the voltmeter when the resistance of the LDR is 1600 Ω.

(b) The Wheatstone bridge is connected to an op-amp as shown.
The output of the op-amp controls the headlights circuit.



The resistance of R_v is adjusted so that the potential at Q is 3.2 V.
At a particular light level, the potential at P is 3.0V.
Determine the output voltage Vo, of the op-amp.