

10. A tower crane transports loads of 25 kN or less on a building site. Figure Q10(a) shows the lifting mechanism. The design specified a **mild-steel** lifting cable with a factor of safety of 6.

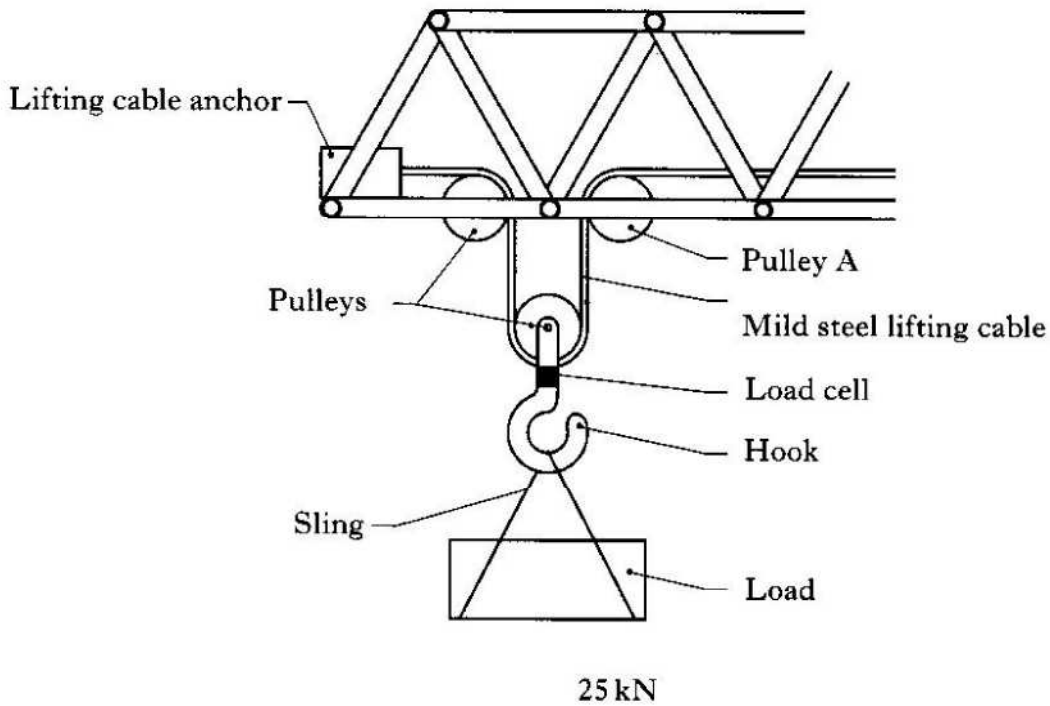


Figure Q10(a)

- (a) Calculate the effective diameter of the lifting cable used in this design.

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An electronic warning device is proposed that will indicate when the load being lifted approaches the maximum permissible value. The circuit for the warning device is shown in Figure Q10(b). An input voltage (V_{in}) is received from the load cell mounted on the lifting hook, as shown in Figure Q10(a). The orange light emitting diode (LED) provides a warning and the red LED shows an overload condition.

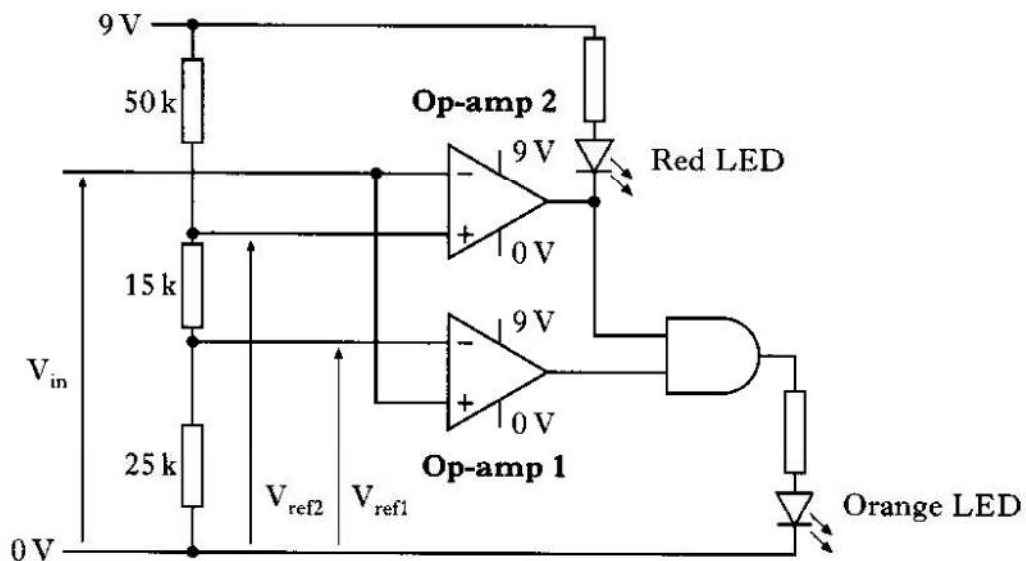


Figure Q10(b)

10. (continued)

Marks

- (b) Describe the operation of the circuit for each of the input conditions below:
- (i) when V_{in} is less than V_{ref1} ; 2
 - (ii) when V_{in} is between V_{ref1} and V_{ref2} ; 2
 - (iii) when V_{in} is greater than V_{ref2} . 2
- (c) Calculate the values of V_{in} at which the output voltage of each op-amp changes. 2

A signal conditioning circuit for the load cell output voltage V_1 is shown in Figure Q10(c). An adjustable input voltage V_2 enables the output voltage V_{out} to be set to zero when there is no load on the hook.

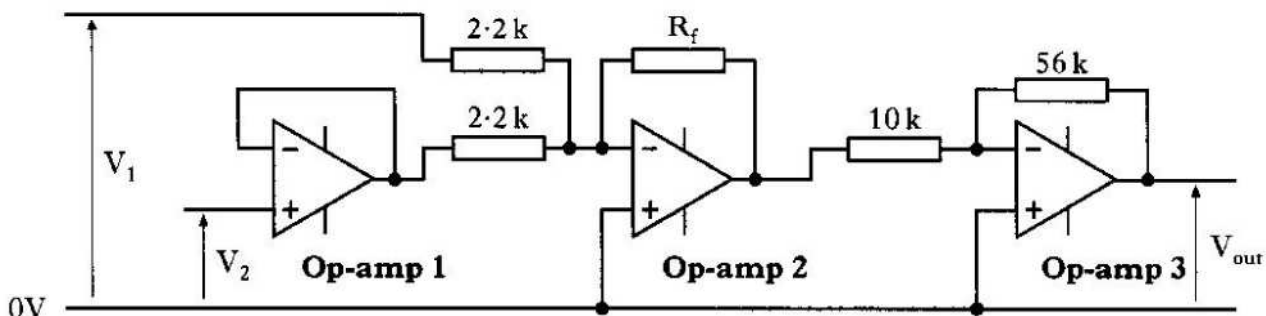


Figure Q10(c)

- (d) Explain the purpose of Op-amp 1 in this circuit. 1

The table below shows one set of readings taken when calibrating the load sensor.

LOAD (kN)	V_1 (mV)	V_2 (mV)	V_{out} (V)
22.0	120	-5	4.391

- (e) Calculate the value of the feedback resistor R_f used in the signal conditioning circuit. 3
- (f) Explain what it means to *calibrate* the load sensor. 1