

- (a) A measurement is carried out to check the speed of a camera shutter of $1/15$ s. The camera is focused symmetrically on a rotating turntable which revolves at 33.3 ± 0.1 revolutions per minute and has a spot at its centre and at its circumference. A photograph shows the arc produced by the spot on the circumference subtends an angle of $12.4 \pm 0.1^\circ$ at the centre of rotation. What is the correct exposure time?

 θ

[3]



θ corresponds to shutter opening time τ

Since speed of rotation ω is constant, spot arc angle $\theta = \omega \tau$

$$\therefore \tau = \frac{\theta}{\omega}$$

$$\tau = \frac{(12.4 \pm 0.1) \text{ degrees}}{(33.3 \pm 0.1) \times \frac{360 \text{ degrees}}{60 \text{ s}}} \quad (5)$$

$$\therefore \frac{12.3 \times 60}{33.4 \times 360} < \tau < \frac{12.5 \times 60}{33.2 \times 360} \quad (5)$$

$$\therefore 6.14 \times 10^{-2} < \tau < 6.28 \times 10^{-2} \quad (5)$$

$$\boxed{\frac{1}{16.3} < \tau < \frac{1}{15.9}}$$

or

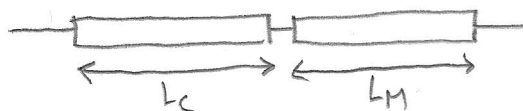
$$\boxed{\tau = (6.21 \pm 0.07) \times 10^{-2} \text{ s}}$$

(b) The temperature coefficients of resistance, α , of certain alloys are positive and others are negative. They have resistance per unit length of r . This makes it possible to produce a resistor, using the two wires in series, which does not vary with temperature. The values of r , at 0°C , and α are given in Table 1.b for constantan and manganin. These wire have lengths L_c and L_m respectively at 0°C . What values of L_c and L_m are required to produce a $5.0\ \Omega$ resistor?

Wire	$r/\Omega\text{m}^{-1}$	$\alpha/^\circ\text{C}^{-1}$
Constantan	6.3	-3.0×10^{-5}
Manganin	5.3	$+1.4 \times 10^{-5}$

Table 1.b

$$r(T) = r_0(1 + \alpha T) \quad [5]$$



$$\text{So } 5.0 = 6.3L_c + 5.3L_m \quad (1) \quad (\text{Resistance equation})$$

This is true at 0°C

$$\text{Now let } r = r_0(1 + \alpha T)$$

where T is temperature in degrees Celsius.

So for total resistance to be $5.0\ \Omega$ at $T \neq 0$

$$\Rightarrow 5.0 = 6.3(1 - 3.0 \times 10^{-5} T)L_c + 5.3(1 + 1.4 \times 10^{-5} T)L_m \quad (2)$$

$$(1) - (2) : 0 = 6.3 \times 3.0 \times 10^{-5} T L_c - 5.3 \times 1.4 \times 10^{-5} T L_m$$

$$\therefore L_c = \frac{5.3 \times 1.4}{6.3 + 3.0} L_m \Rightarrow L_c = 0.393 L_m$$

Calc memory = A

$$\text{In } (1) : 5.0 = 6.3 \times A L_m + 5.3 L_m$$

$$\therefore L_m = \frac{5.0}{6.3A + 5.3} = 0.64 \text{ m}$$

$$\therefore L_c = 0.25 \text{ m}$$

