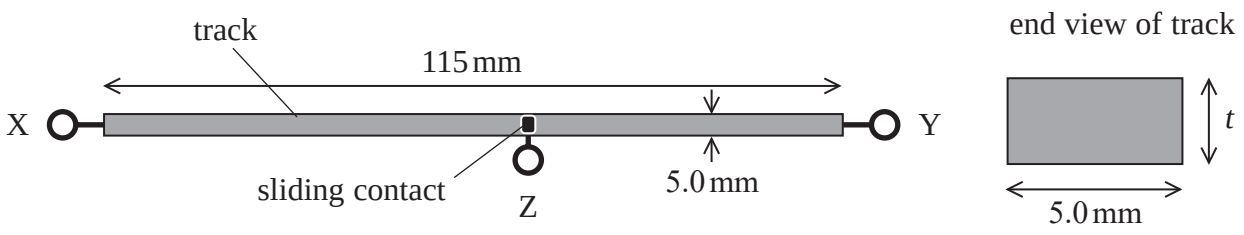
18 A potential divider circuit may contain a component known as a potentiometer. One type of potentiometer consists of a track with terminals X and Y at either end. There is a sliding contact that can move along the track connected to a terminal Z as shown.



The length of the track is 115 mm and the width is 5.0 mm.

(a) The resistance of the track between terminal X and terminal Y is 12.0 kΩ.

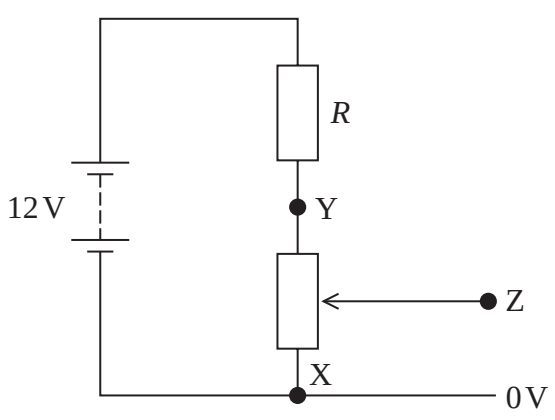
Calculate the thickness *t* of the track.

resistivity of track material = 0.49 Ω m

(3)

t = ...

(b) The potentiometer is used to monitor the displacement of a moving tool on a machine in a production line. The tool is attached to the sliding contact. The potentiometer is connected to a resistor of resistance *R* and a potential difference is applied as shown. The tool moves through a maximum displacement of 60 mm from end X, producing a maximum potential difference of 5.0 V between Z and X.



(i) Show that the potential difference between X and Y is about 10 V.

(2)

(ii) Calculate the value of *R*.

(3)

R = ...

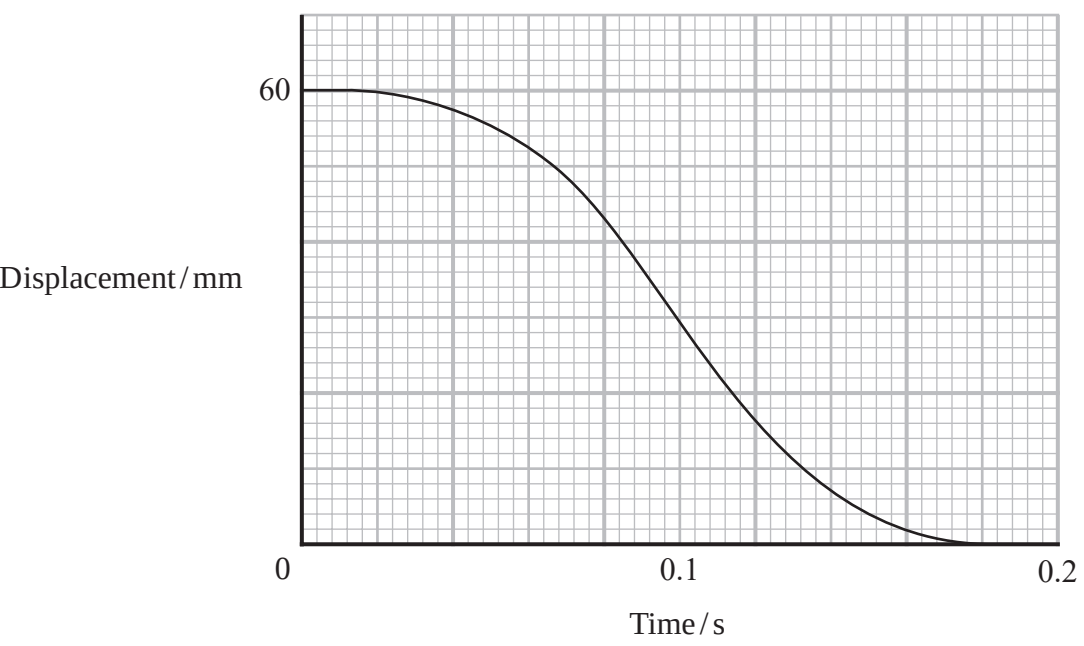
(iii) When the circuit is assembled, using the correctly calculated resistance value and a battery of e.m.f. 12 V, it is found that the maximum output from the potentiometer is slightly less than 5.0 V.

Explain why the maximum output is slightly less than predicted.

(3)

(iv) The tool on the machine should not travel with a speed any larger than 0.8 m s^{-1}.

The graph shows how the displacement varies with time for the downward stroke of the moving tool.



Deduce whether this speed is exceeded by the moving tool.

(4)

(Total for Question 18 = 15 marks)