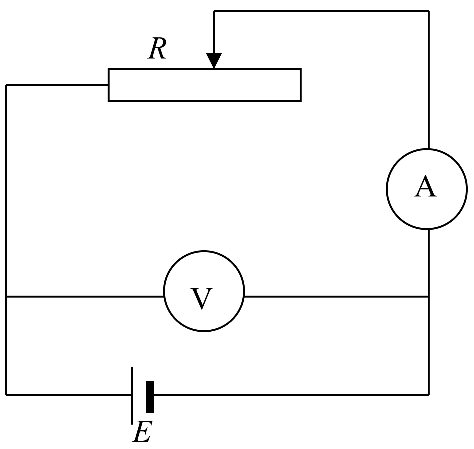
Experimental problem

The circuit is given in the figure below:

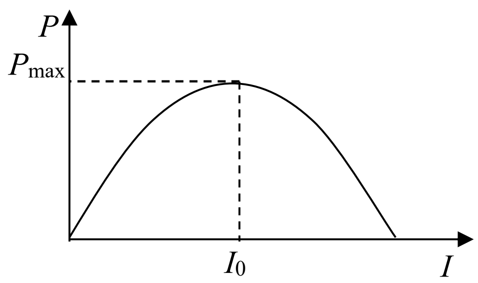


Sliding the contact along the rheostat sets the current I supplied by the source. For each value of I the voltage U across the source terminals is recorded by the voltmeter. The power dissipated in the rheostat is:

$$P = UI$$

provided that the heat losses in the internal resistance of the ammeter are negligible.

1. A typical P–I curve is shown below:



If the current varies in a sufficiently large interval a maximum power P_{max} can be detected at a certain value, I_0, of I. Theoretically, the $P(I)$ dependence is given by:

(5.1) $$P = EI - I^2 r,$$

where E and r are the EMF and the internal resistance of the dc source respectively. The maxim value of P therefore is:

(5.2) $$P_{max} = \frac{E^2}{4r},$$

and corresponds to a current:

(5.3) $$I_0 = \frac{E}{2r}.$$

2. The internal resistance is determined trough (5.2) and (5.3) by recording P_{max} and I_0 from the experimental plot:

$$r = \frac{P_{max}}{I_0^2}.$$

3. Similarly, EMF is calculated as:

$$E = \frac{2P_{\max}}{I_0}.$$

4. The current depends on the resistance of the rheostat as:

$$I = \frac{E}{R+r}.$$

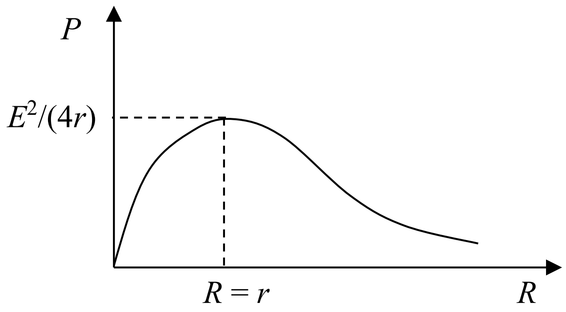
Therefore a value of R can be calculated for each value of I:

(5.4) $$R = \frac{E}{I} - r.$$

The power dissipated in the rheostat is given in terms of R respectively by:

(5.5) $$P = \frac{E^2 R}{(R+r)^2}.$$

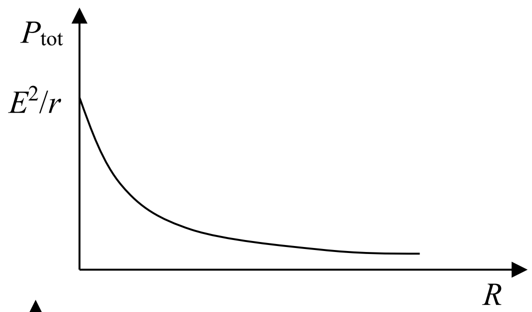
The P–R plot is given below:



Its maximum is obtained at $R = r$.

5. The total power supplied by the dc source is:

(5.6) $$P_{tot} = \frac{E^2}{R+r}.$$



6. The efficiency respectively is:

(5.7) $$\eta = \frac{P}{P_{tot}} = \frac{R}{R+r}.$$