

Exercise walk-through

## 2.7

# Potential dividers, sensors and e.m.f. (statements 74–80, core practical 8)

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## Intensity needs an area conversion

- 1 **Convert**  $A = 25 \times 10^{-4} = 0.0025 \text{ m}^2$
- 2 **Incident**  $P = IA = 800 \times 0.0025 = 2.0 \text{ W}$
- 3 **Useful**  $P_{out} = \eta P = 0.20 \times 2.0 = 0.40 \text{ W}$

### Decision

A 0.50 W device cannot run from this useful output.

## Frequency and intensity change different things

| Change                              | Photon energy | Maximum electron energy      |
|-------------------------------------|---------------|------------------------------|
| Intensity rises;<br>frequency fixed | Unchanged     | Unchanged                    |
| Frequency rises                     | Increases     | Increases above<br>threshold |

## Exercise 2.1

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**2.1** A uniform wire of length 1.20 m has 6.0 V across it at steady temperature. Find the drop across 0.30 m. Explain why potential varies linearly with distance. [3]

0.30 m



1.20 m, 6.0 V

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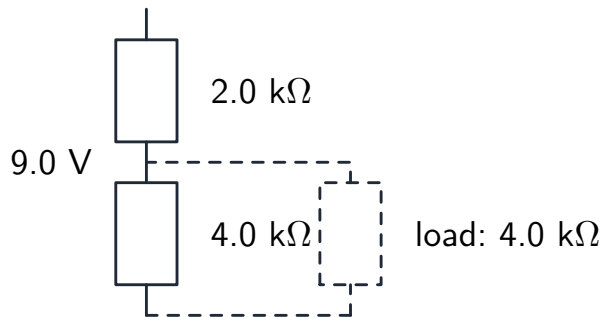
1.20 m, 6.0 V

**2.1**  $V_x = V_{total}x/L = 6.0 \times 0.30/1.20 = 1.5$  V. Uniform wire resistance is proportional to length; the same current flows throughout, so  $V = IR$  gives drop proportional to length.

## Exercise 2.2

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**2.2** A 9.0 V unloaded divider contains an upper  $2.0\text{ k}\Omega$  resistor and lower  $4.0\text{ k}\Omega$  resistor. Find output across the lower resistor. A  $4.0\text{ k}\Omega$  load is then attached across the output. Find the new output. [3]



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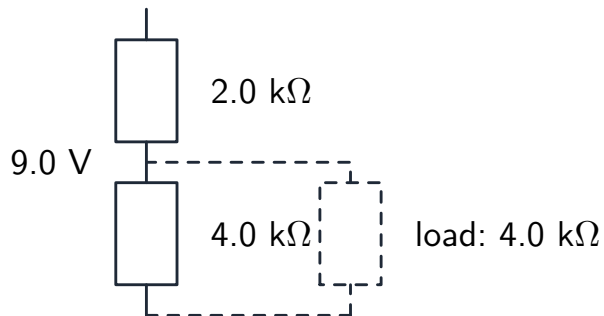
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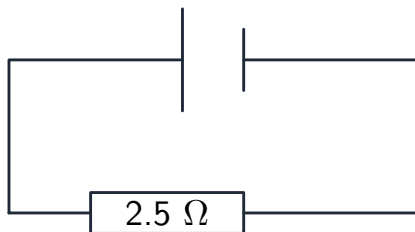
**2.2** Unloaded  $V_o = V_i R_2 / (R_1 + R_2) = 9 \times 4/6 = 6.0 \text{ V}$ . Loaded lower resistance is  $4 \parallel 4 = 2.0 \text{ k}\Omega$ . New  $V_o = 9 \times 2/(2 + 2) = 4.5 \text{ V}$ .

## Exercise 2.3

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**2.3** A cell has e.m.f.  $1.5\text{ V}$  and internal resistance  $0.50\ \Omega$ . It supplies a  $2.5\ \Omega$  resistor. Find current, terminal p.d. and internal heating power. [3]

cell:  $1.5\text{ V}$ ,  $0.50\ \Omega$



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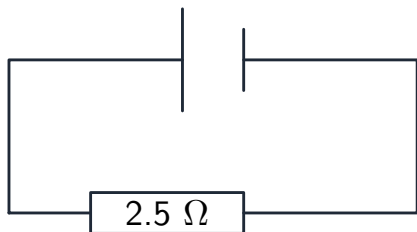
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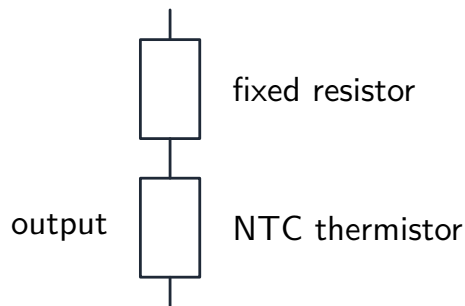
cell:  $1.5 \text{ V}$ ,  $0.50 \Omega$



**2.3**  $I = \mathcal{E}/(R + r) = 1.5/3.0 = 0.50 \text{ A}$ .  $V = \mathcal{E} - Ir = 1.5 - 0.50 \times 0.50 = 1.25 \text{ V}$ .  
 $P_{int} = I^2 r = 0.50^2 \times 0.50 = 0.125 \text{ W}$ .

## Exercise 3.1

**3.1** A divider has an upper fixed resistor and a lower NTC thermistor. The output is across the thermistor. Explain the full effect of heating on output. Contrast the carrier model with a heated metal wire, and explain what increasing illumination does to an LDR. [6]



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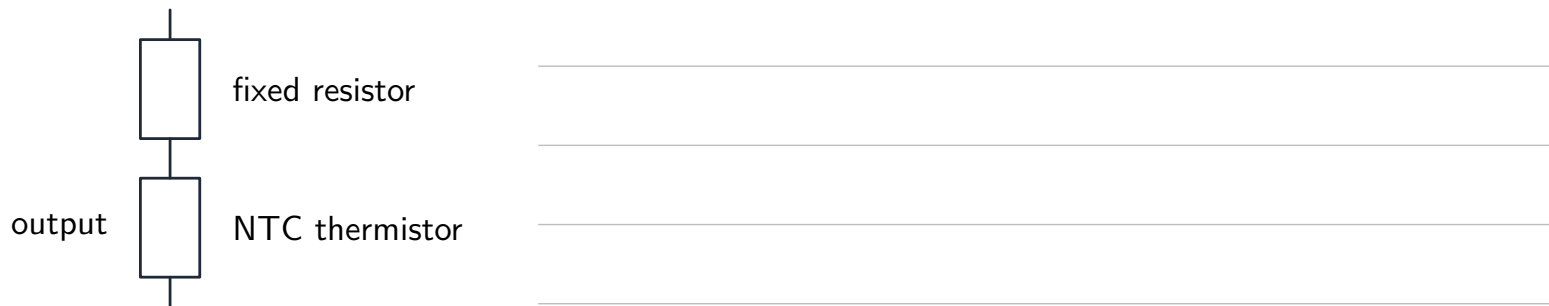
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**3.1** Heating the thermistor releases more mobile carriers, reducing its resistance. Its fraction  $R_T/(R_f + R_T)$  decreases, so the named output falls. In metal, increased lattice scattering dominates with approximately unchanged carrier density, so resistance rises. Illumination releases more carriers in an LDR, reducing its resistance.

## Exercise 3.2

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**3.2** Plan a graph experiment for cell e.m.f. and internal resistance. A best-fit terminal-voltage line passes through (0.10 A, 1.45 V) and (0.50 A, 1.25 V). Calculate e.m.f. and internal resistance. State why short-circuiting is unsuitable. [6]

|      |
|------|
| cell |
|------|

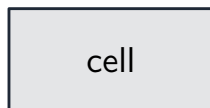
0.10 A, 1.45 V

0.50 A, 1.25 V

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0.10 A, 1.45 V

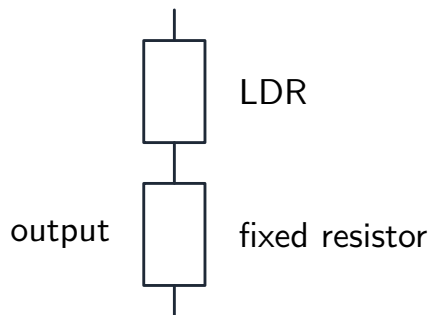
0.50 A, 1.25 V

**3.2** Use an ammeter and variable external load in series; voltmeter across the cell. Record several  $V, I$  pairs and plot  $V$  against  $I$ . From  $V = \mathcal{E} - Ir$ , gradient  $= -r$  and intercept  $= \mathcal{E}$ .  $r = -\Delta V / \Delta I = -(1.25 - 1.45) / (0.50 - 0.10) = 0.50 \, \Omega$ .  $\mathcal{E} = V + Ir = 1.45 + 0.10 \times 0.50 = 1.50 \, \text{V}$ . Short-circuit current causes heating and can change cell conditions or damage the cell; use current limiting and open the switch between readings.

## Exercise 3.3

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**3.3** An unloaded divider has an upper LDR and a lower fixed resistor. The output is across the fixed resistor. Explain how increasing illumination changes the output, using a carrier model. State why the opposite output trend occurs if the two resistors exchange places. [4]



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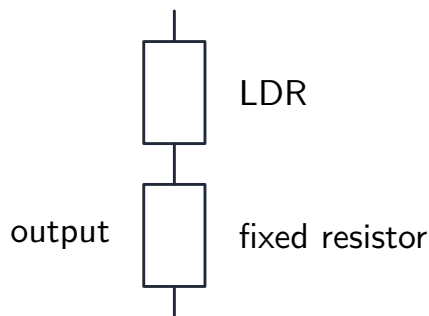
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**3.3** Illumination releases additional mobile carriers in the LDR, so its resistance decreases. With fixed resistor below,  $R_f/(R_{LDR}+R_f)$  rises, so the output rises. With the LDR below, its own fraction  $R_{LDR}/(R_f + R_{LDR})$  falls, so the output falls.