

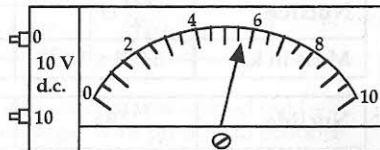
## Miscellaneous

### Exercise 11.1 Uncertainties

1. When a ball is dropped six times, the rebound heights are:  
1.71 m, 1.78 m, 1.72 m, 1.76 m, 1.73 m, 1.74 m

- a) Calculate the mean value of the height of the bounce.  
b) Calculate the random uncertainty in this value.

2. The diagram shows the reading obtained on a voltmeter during an experiment.



- a) Write down the voltmeter reading and its uncertainty.  
b) Explain how you arrived at your value for the uncertainty.

3. Measurements of the p.d. across a resistor and the current in the resistor give the following results.

$$\begin{aligned} \text{p.d.} &= 30.00 \pm 0.03 \text{ V} \\ \text{current} &= 2.00 \pm 0.01 \text{ A} \end{aligned}$$

Use these results to calculate the value of the resistance and express your answer in the form "resistance  $\pm$  absolute uncertainty".

4. In an experiment to determine the specific heat capacity of a liquid, the liquid was heated in an insulated container using an immersion heater. The following results were obtained.

$$\begin{aligned} \text{Heater current} &= 5.0 \pm 0.2 \text{ A} \\ \text{Heater voltage} &= 12.0 \pm 0.5 \text{ V} \\ \text{Time for which current flows} &= 100 \pm 1 \text{ s} \\ \text{Mass of liquid} &= 1.000 \pm 0.005 \text{ kg} \\ \text{Rise in temperature} &= 10 \pm 1 \text{ }^\circ\text{C} \end{aligned}$$

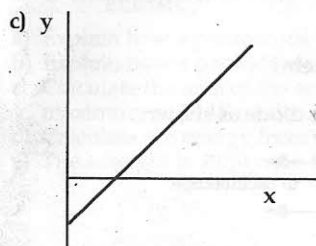
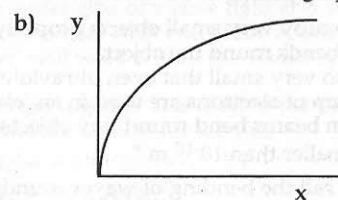
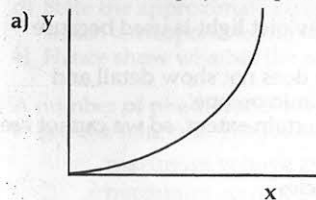
- a) Calculate the value of the specific heat capacity of the liquid.  
b) Identify which of the measurements given above has the largest percentage uncertainty.  
c) Determine the absolute uncertainty in the value of the specific heat capacity.
5. An experiment to measure the speed of sound gave the following results.
- $$\begin{aligned} \text{Distance} &3.000 \pm 0.005 \text{ m} \\ \text{Time} &8.78 \text{ ms}, 8.98 \text{ ms}, 8.73 \text{ ms}, 8.89 \text{ ms} \end{aligned}$$
- a) i) Calculate the mean time.  
ii) Calculate the random uncertainty in the time measurement.  
b) From the results, calculate the speed of sound in air and the uncertainty in this calculated value.  
Express your answer as "speed  $\pm$  absolute uncertainty".  
c) Suggest **one** way in which the uncertainty in the speed could be reduced.

### Exercise 11.2 Mixed Problems

1. One million kilograms of water per minute flow through the turbines of a hydroelectric power station, after falling through a height of 50 m. The turbines develop a useful power output of 5 MW.

Calculate the percentage efficiency of the energy conversion.

2.  $x$  and  $y$  are two physical quantities related as shown in the three graphs.



For each graph, state the most likely relationship between  $x$  and  $y$ .

3. a) Describe an experiment to investigate how the rate at which heat is produced in a coil of wire varies with the current in the wire. Include in your answer
- a labelled diagram of the apparatus used,
  - a description of the experimental measurements made,
  - details of any measures taken to minimise experimental errors.
- b) In such an experiment the following results were obtained.

Rate of heat production/ $\text{J s}^{-1}$	1.9	3.2	11	16	24
Current in wire/A	0.7	0.9	1.6	2.0	2.4

- i) Use these results to determine the relationship between the rate of production of heat and the current in the wire.  
ii) From the above results determine the resistance of the wire.
4. Two pupils both measure impulse, one in  $\text{kg m s}^{-1}$  and the other in  $\text{N s}$ . Show that these two sets of units are identical.
5. Show that the units  $\text{V m}^{-1}$  (volts per metre) and  $\text{N C}^{-1}$  (newtons per coulomb) are identical.
6. What single unit can be used to measure 'force  $\times$  velocity'?

7. The force of attraction  $F$  between two planets of mass  $m_1$  kilograms and  $m_2$  kilograms, a distance  $d$  metres apart is given by:

$$F = \frac{k m_1 m_2}{d^2}$$

What are the units of the constant of proportionality  $k$ ?

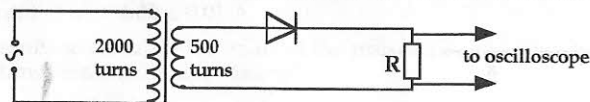
8. Read the following passage.

"In order to study very small objects properly, ultraviolet light is used because visible light bends round the object.

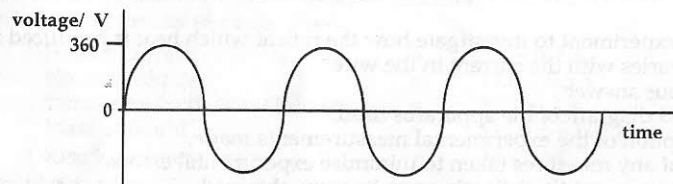
Viruses are so very small that even ultraviolet light does not show detail and instead a beam of electrons are used in an 'electron microscope'.

Even electron beams bend round tiny objects to a certain extent, so we cannot see any detail smaller than  $10^{-10}$  m."

- a) What do we call the bending of waves round obstacles?  
 b) Explain why ultraviolet light shows more detail than visible light in advanced microscopy.  
 c) Electrons are normally considered as tiny particles. What does the above short passage imply about them?
9. An a.c. supply is connected through a transformer to a diode as shown.



The input voltage is shown in the diagram.



Sketch the resulting voltage output across  $R$ .

10. In a school workshop, a small transformer is used to operate an electric drill from the 230 V, 50 Hz mains. The voltage across the drill is 120 V and the current through it is 2 A (both r.m.s).

Assuming no energy losses in the coil of the transformer, what is the peak current in the primary?

11. A photocell is illuminated with monochromatic light. The photocell is made with a material which has a work function of  $2.8 \times 10^{-19}$  J. The wavelength of the light is measured using a diffraction grating with 600 lines per millimetre. The first order line is found at  $4.85^\circ$ .

- a) Calculate the wavelength of light used.  
 b) Calculate the frequency of light used.  
 c) Show by calculation, whether the light will be able to remove electrons from the surface of the photocell.  
 d) State the approximate range of wavelengths of visible light and state the colours which correspond to the wavelengths near each end of the spectrum.  
 e) Hence show whether the photocell will work within the visible spectrum.

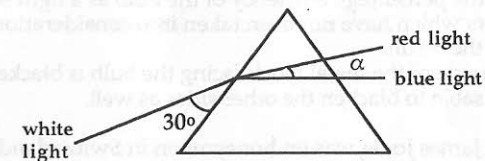
12. A number of photodiodes are connected together and used in the photovoltaic mode to act as a solar cell. The following data is available for the cell.

maximum voltage available = 0.5 V

maximum current available = 30 mA cm<sup>-2</sup>

efficiency = 15 %

- a) Explain how a photodiode is constructed.  
 b) Explain how a photodiode is able to convert light into electrical energy.  
 c) Calculate the area of the solar cell, in square metres, if it is able to supply a maximum of 10 W of electrical power.  
 d) Calculate the energy from the Sun falling on the solar cell each second.  
 e) The sunlight is allowed to fall on a prism as shown.



Find the size of the angle  $\alpha$  if the refractive index of red light is 1.50 and that of blue light is 1.53 for the prism used.

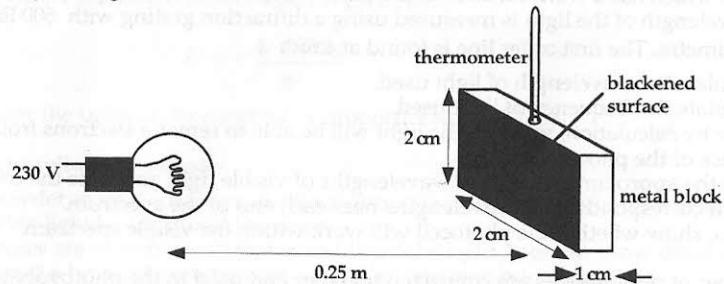
13. Water enters the heater unit of a shower at a temperature of 5 °C and emerges from the shower head at a temperature of 44 °C. The water passing through the shower is collected for a period of 15 s and the mass of water is measured. This is repeated several times giving the following results.

mass of water    580 g, 572 g, 594 g, 554 g

Calculate the rate, in watts, at which the water gains energy, including an estimate of the uncertainty caused by the mass measurement.

(Specific heat capacity of water is 4180 J kg<sup>-1</sup> °C<sup>-1</sup>.)

14. The apparatus in the sketch (not to scale) shows a pupil's attempt to measure the efficiency of a light bulb marked 250 W, 230 V.



The metal block measured 2 cm x 2 cm x 1 cm and has a mass of 0.036 kg. It was blackened on the side facing the bulb and set 0.25 m from the centre of the bulb. The bulb was switched on for 4 minutes and it was found that the temperature of the block rose from 18.20 °C to 19.50 °C.

- Calculate the quantity of heat absorbed by the block in the 4 minutes.  
(Specific heat capacity of the metal block is  $400 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}$ .)
  - Estimate, therefore, the total heat energy radiated from the bulb in 1 s.  
(Surface area of a sphere is  $4\pi r^2$  and  $\pi = 3.14$ .)
  - If it is assumed that the energy not radiated as heat is converted into light, how much energy is converted into light in 1 s?
  - Hence calculate the percentage efficiency of the bulb as a light source.
  - State **three** factors which have **not** been taken into consideration and say how each one could affect the result.
  - Explain why the side of the metal block facing the bulb is blackened and why it would be inadvisable to blacken the other sides as well.
15. It is said that when James Joule was on honeymoon in Switzerland, he investigated the conversion of potential energy to heat by attempting to detect a difference in the water temperature between the top and bottom of a waterfall.
- Calculate the maximum temperature difference he could have expected for a 50 m high waterfall.  
(Specific heat capacity of water is  $4180 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}$ .)
    - Explain why the temperature difference would not be this great.
  - In order to measure this difference in temperature he used a very sensitive mercury in glass thermometer.  
Explain what is meant by 'sensitive' in this context.
    - How would a mercury in glass thermometer be designed to be sensitive?