Q6 The value of g obtained by this method can be affected by systematic errors in the experiment.

Explain what is meant by the term "systematic error".

An error (constant) which is due to the measurement process or apparatus.

Q7 Explain how the factors listed below could affect the final calculated result for g. State whether the value of g is likely to be high, or low, with reasons.

1. Frictional forces due to rolling resistance of the trolley wheels.

Frictional forces OPPOSE the motion, therefore the accelerating force is less, so small acceleration. Since $g = \frac{a}{\sin\theta}$ the final value of g will be smaller.

2. Energy losses due to the viscosity of air.

When the trolley falls PE → KE, but if some PE is lost to the air there is less KE available $KE = \frac{1}{2}mv^2$, so if KE is too low, v is too low, and a is too low – so (eventually) g is too low!

Q8 An electronic timer and light gate give a reading of $2.32 \pm 0.01\ ms^{-1}$ when $\theta = 20.0°$ and $S = 0.80m$.

Calculate the maximum and minimum values of g indicated by this data and so express a final answer as an average value of g with a % uncertainty.

$a = \frac{v^2}{2S}$ $g = \frac{a}{\sin\theta}$ so $g = \frac{v^2}{2S\sin\theta}$.

$g_{MAX} = \frac{2.33^2}{2 \times 0.8 \times \sin 20} = 9.92\ ms^{-2}$

$g_{min} = \frac{2.31^2}{2 \times 0.8 \times \sin 20} = 9.75\ ms^{-2}$

$g_{average} = 9.836\ ms^{-2}$

% uncertainty $= \frac{0.17 \times 100}{9.836 \times 2}$

$= \pm 0.86\%$

best answer $g = 9.84 \pm 0.9\%\ ms^{-2}$

Measuring the speed of light

Q1 Calculate the approximate time taken for light to travel one mile. [1 mile = 1.609km]

$s = \frac{d}{t}$ so $t = \frac{d}{s} = \frac{1.609 \times 10^3}{2.997 \times 10^8} = 5.34 \times 10^{-6}$ s

ie 5.34 μs

Q2 Explain why Galileo's method failed given that the best human reaction time is around 0.1s.

The light transit time is a very small fraction of the human reaction time, so is unmeasurable.

Q3 Using the *minimum* value that Michelson measured, calculate the percentage error compared with the modern accepted value for c quoted in the article.

modern value $= 2.99792 \times 10^8$ ms^{-1}

Michelson $= (2.99910 \times 10^8 - 50 \times 10^3)$ ms

$= 2.9986 \times 10^8$

% error $= \frac{2.9986 - 2.99792}{2.99792} \times 100 = 2.27 \times 10^{-2}$ %

Q5 A microwave oven is made with a rectangular metal cavity inside as shown below [Fig.3]

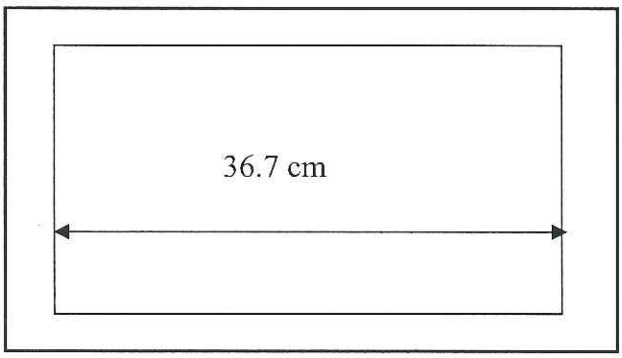


Fig.3

Draw inside the box the likely linear horizontal standing wave pattern that could be set up if 2.45GHz microwaves are fed into the oven. Assume that there is a node at each metal wall.

On the wave pattern indicate with an H where the "chocolate hotspots" are going to be located.

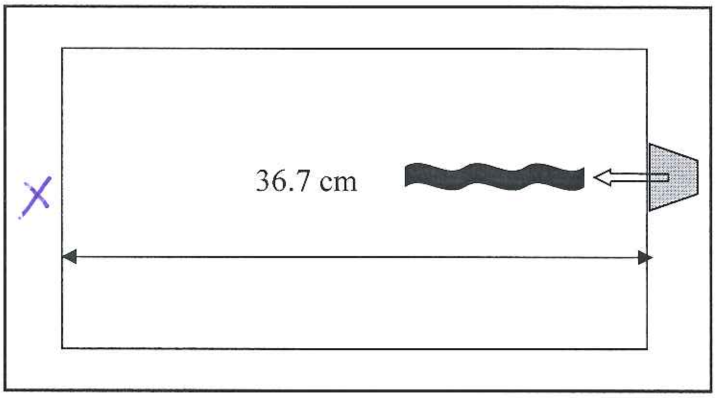
Q7 A student measures the distance between hotspots to be 5.9cm ± 0.5cm. What are the minimum and maximum values of the speed of light indicated by this data?

distance $= \frac{\lambda}{2}$ $d_{min} = 5.4$ cm $d_{max} = 6.4$ cm

$c = f\lambda$ so $c_{min} = 2.45 \times 10^9 \times 5.4 \times 10^{-2} \times 2 = 2.65 \times 10^8$ ms^{-1}

$c_{max} = 2.45 \times 10^9 \times 6.4 \times 10^{-2} \times 2 = 3.14 \times 10^8$ ms^{-1}

Q8 A microwave oven contains a device called a magnetron which produces high energy microwave oscillations. These can be fed into the oven cavity from the side as shown in Fig.4



Explain how standing waves can be set up in the microwave cavity.

Fig.4

The waves are reflected at X on the opposite wall. This produces two equal and opposite travelling (progressive) waves, which superpose to produce a standing wave.