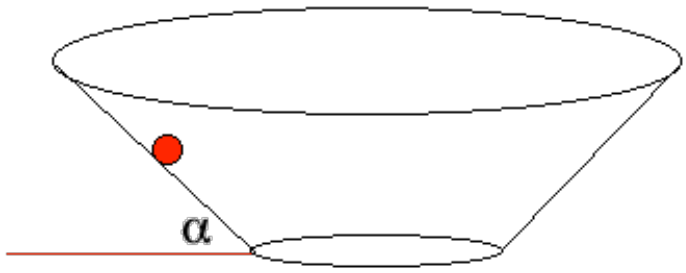
Answer all questions. Answers must be written in the answer boxes provided.

1 (a) A small ball of mass m is moving in a horizontal circle on the inside surface of a frictionless conical bowl.

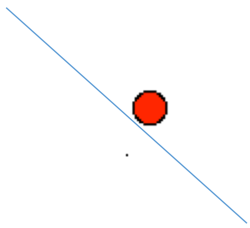


(i) State the direction of the resultant force on the ball.

[1]

(ii) On the diagram below, draw two arrows of the correct relative length to represent the normal force and weight of the ball.

[3]



(iii) Show that the magnitude of the resultant force on the ball is given by:

[3]

$$F = \frac{mg}{tan\alpha}$$

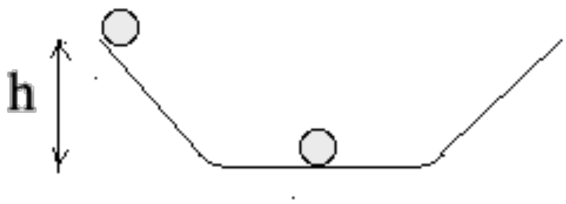
(iv) If α = 45° calculate the radius of the circle for a speed of 1.2 ms^{-1}.

[3]

(v) The ball is replaced by the bigger one shown below. Deduce whether or not this ball will follow the same path as the small one when travelling round the bowl at the same speed.

[2]

d) Two identical magnetic steel balls are placed in the bowl, one at the bottom and one at the top.



The upper ball is released and hits the lower ball. The two balls remain in contact. Show that the maximum height the balls could reach is h/4.

[3]

2. (a) A 50 cm^3 syringe is filled with helium gas at room temperature (300 K) and atmospheric pressure (100 kPa). At this temperature and pressure helium behaves as an ideal gas.

(i) State what is meant by an ideal gas.

[1]

(ii) Calculate the number of moles of helium in the syringe.

[1]

(iii) Calculate the internal energy of the helium in joules.

[2]

(b) The end of the syringe is closed and the volume reduced to 45 cm^3 at constant temperature.

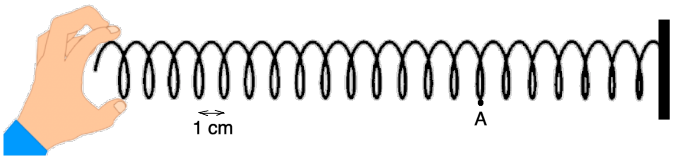
(i) Calculate the new pressure in kPa.

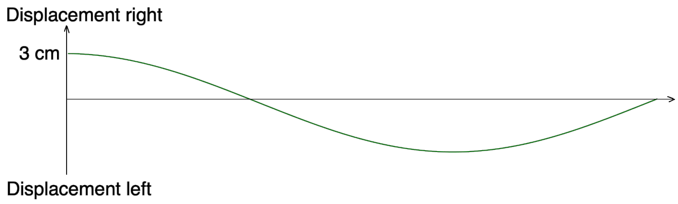
[1]

(ii) Use the kinetic model to explain this change in pressure.

[2]

3. (a) The diagram represents a slinky spring attached to a wall on the right and held in a hand on the left. The hand is moved left and right causing a longitudinal standing wave to be set up in the spring. The graph shows the displacement of the different coils of the spring at one moment in time.





(i) Outline how the standing wave is formed.

[1]

Point A represents a point on the undisturbed spring.

(ii) Put a cross on the spring at the position of point A at the time of the graph.

[1]

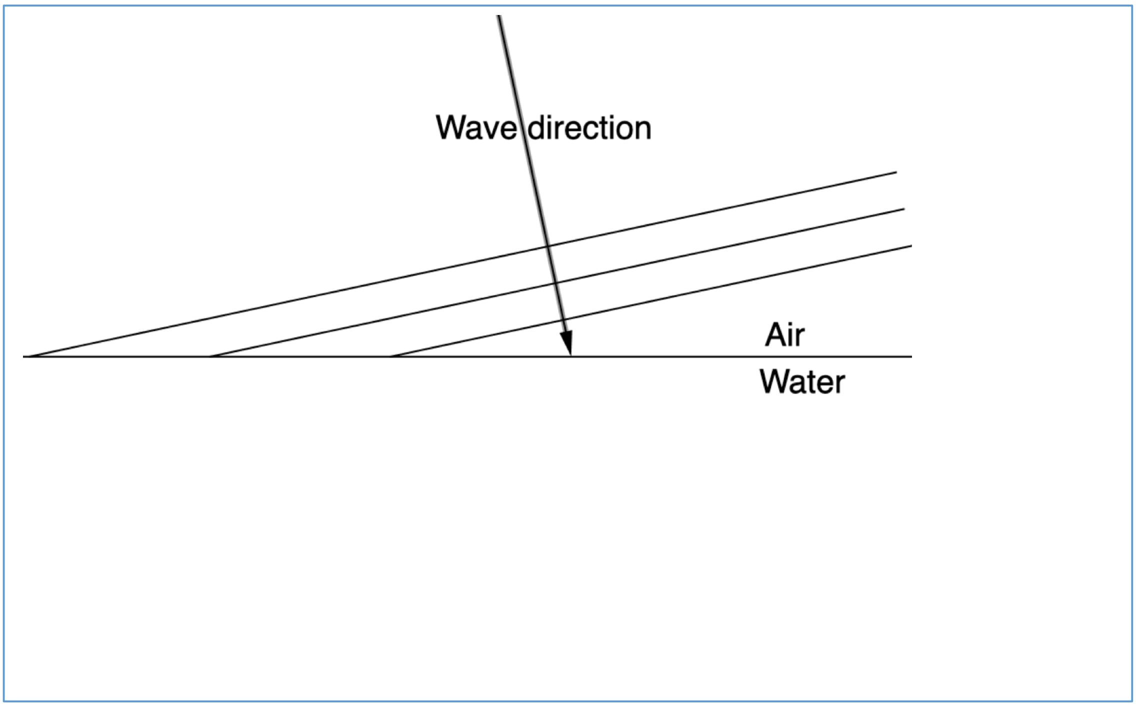
(iii) Label two nodes on the spring with the letter N.

[1]

(iv) The frequency of the hand is 0.5 Hz. calculate the velocity of the wave.

[2]

(b) A sound wave from a distant source produces parallel wavefronts incident on the surface of a swimming pool at an angle just less than the critical angle.



(i) State what is meant by the term critical angle.

[1]

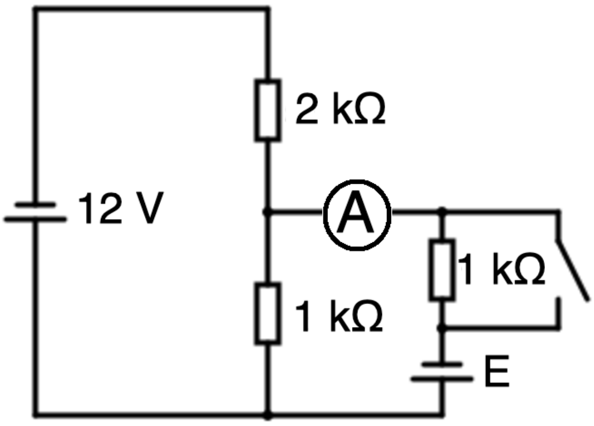
(ii) Draw the 3 wavefronts after passing into the water.

[2]

(iii) The speed of sound in air is 340 ms^{-1} and in water 1500 ms^{-1}. Calculate the critical angle. Give your answer to the correct number of significant figures.

[2]

4. The circuit diagram represents a potential divider. The ammeter reads 0A



(a)

(i) E represents the emf of the cell, state what is meant by emf.

[2]

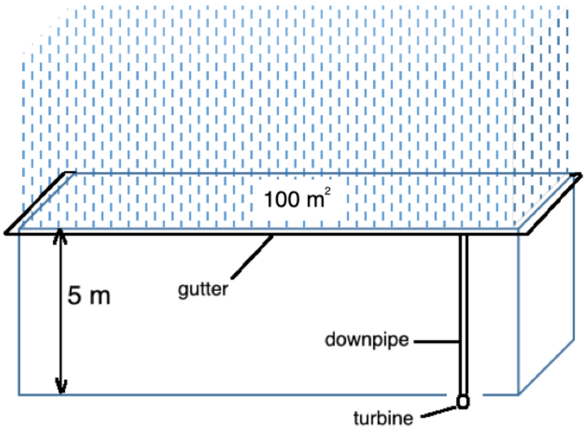
(ii) Determine E.

[2]

(iii) Deduce the effect, if any, that closing the switch would have on the ammeter reading.

[2]

5. During a storm a group of students investigate the feasibility of using rainwater collected on the roof of their physics lab to generate electrical energy. In 1 hour 16 mm of rain fell onto the 100 m^2 roof of the building which is 5 m high.
The density of water is 1.00 x 10^3 kgm^{-3}



(a) Calculate the energy stored after 1 hour of rain.

[2]

(b) One plan was to pass the water through a turbine connected to the downpipe of the gutter system without collecting it in a tank. Assuming the turbine / generator is 100% efficient calculate the power output of the system.

[1]

(c) (i) An alternative plan was to collect the water in a tank then let it flow through the turbine. Calculate how the maximum time that a 100 W light bulb could be switched on for using this system.

[1]

(i) Explain why using a tank will result in the loss of energy.

[1]

6. (a) Describe the Rutherford model of the atom.

[2]

(b) Krypton - 90 ($^{90}_{36}Kr$) is a possible result from the fission on a uranium nucleus.

(i) Explain why this nucleus decays by emitting a beta minus particle.

[2]

(ii) The binding energy per nucleon of Krypton - 90 is 8.59 MeV, this decays into rubidium – 90 which has a binding energy per nucleon of 8.63 MeV. Calculate the energy released in the decay.

[1]

(iii) Explain how the kinetic energy of the beta minus can be less than the energy released.

[2]

c) The Bohr model is a modification of the Rutherford model that attempts to explain the Hydrogen spectrum.

(i) Describe the feature of the spectrum that is successfully explained by the model.

[1]

(ii) Describe one feature of the spectrum that is not explained by the Bohr model.

[1]

Bohr introduced the condition that the angular momentum of orbiting electrons is quantized.

$$mvr = \frac{nh}{2\pi}$$

(ii) Using this condition show that the radius of electron orbits will be given by the expression

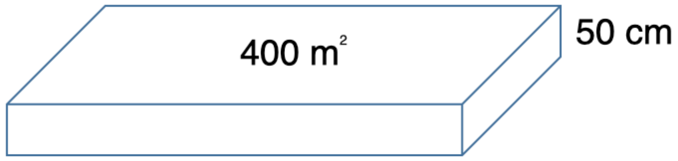
$$r = \frac{\mathcal{E}_0 n^2 h^2}{\pi m e^2}$$

[3]

(iv) Use the Heisenberg's uncertainty principle to explain why the electrons orbital radii can not be given by this equation.

[2]

7. The ceiling of a 400 m^2 underground carpark is constructed of 2 layers of steel separated by 50 cm of concrete.



Relative Permitivity of concrete = 6
Resistivity of concrete = 150 Ωm

a) (i) Calculate the capacitance of the ceiling.

[1]

(ii) Calculate the energy stored when the potential difference between the plates is 1 kV

[2]

(iii) Calculate the resistance of the concrete between the layers of steel.

[1]

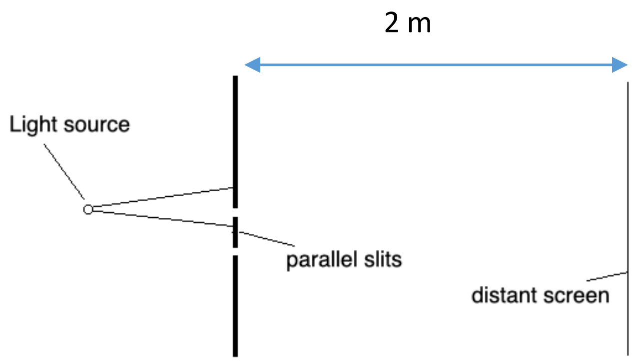
b) (i) After charging to 1 kV the ceiling is isolated. Explain why the potential difference decreases exponentially.

[2]

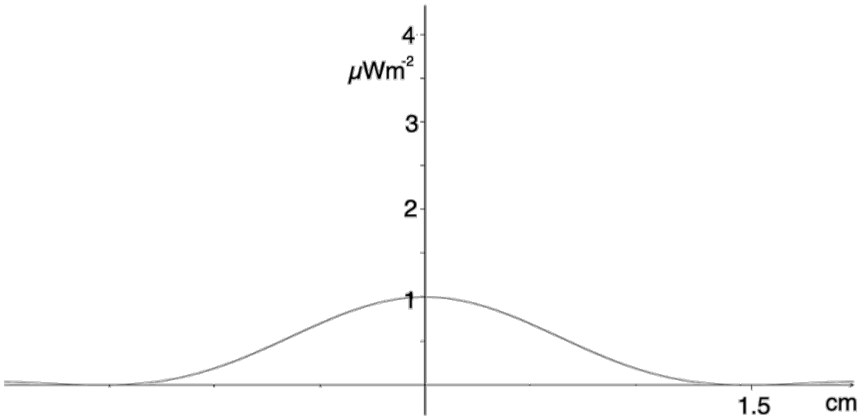
(ii) Calculate the time taken for the potential difference to reach 500 V.

[3]

8. A light source is used to illuminate one slit of a parallel slit arrangement as shown. The separation of the slits is 4x their width.



The light is diffracted forming a pattern on the screen with the following variation in intensity.



a) (i) If the wavelength of the light is 600 nm calculate the width of the slit.

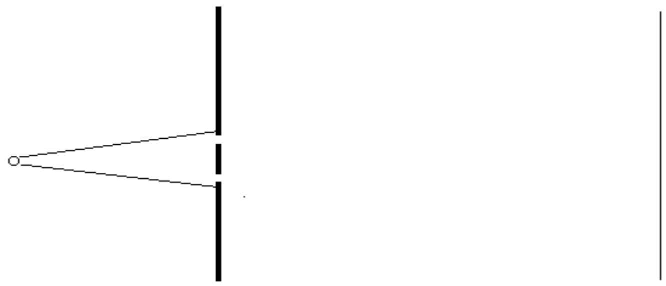
[2]

A second light source of the same wavelength is used to illuminate the other slit.

(iii) Using the axis above draw the variation of intensity for this situation.

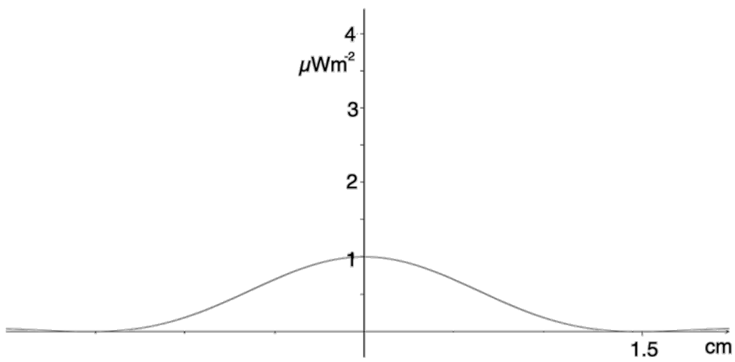
[1]

The second source is now removed and the original source is moved so that it illuminates both slits.



(iv) Using the axis below draw the variation intensity for this situation. Show any calculation in the box provided.

[4]



9. A 500 kg wheeled vehicle lands on a 2 km radius spherical asteroid of mass 10^{15} kg.

a) (i) Calculate the normal force experienced by the vehicle.

[3]

The vehicle travels across the surface of the asteroid at 2 ms^{-1}.

(ii) Explain why the normal force is less than before.

[2]

c) Calculate the new normal force.

[3]

d) Calculate the maximum speed that the vehicle can achieve on the surface of the asteroid.

[2]

The vehicle is powered by an electric motor that drives the wheels.

e) Explain why the vehicle will not be able to accelerate up to the maximum speed calculated in part (v)

[3]

b) A ball is thrown upwards from the surface of the asteroid with a speed of 4 ms^{-1}.

(i) Determine how far the ball travels before it starts to return-

[3]

(ii) Calculate the escape velocity from the asteroid.

[1]