Name: ____________________________ (   ) CT Group: 21S0 _______

RAFFLES INSTITUTION

2020 YEAR 5 TERM 3 TIMED PRACTICE

24 June 2020

H2 PHYSICS

Section B

INSTRUCTIONS TO CANDIDATES

Write your name, index number and CT Group.

Write your answers to Section B in the spaces provided on the question paper.

For Examiner's Use		
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Deductions		
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This document consists of 15 printed pages.

12 **(a)** A student drains the water from a fully filled rectangular water tank of length L, width w and height h into a drain by using a tube of cross-sectional area A, as shown in Fig. 12.1. The drain is located at a vertical distance d below the surface of the water in the tank.

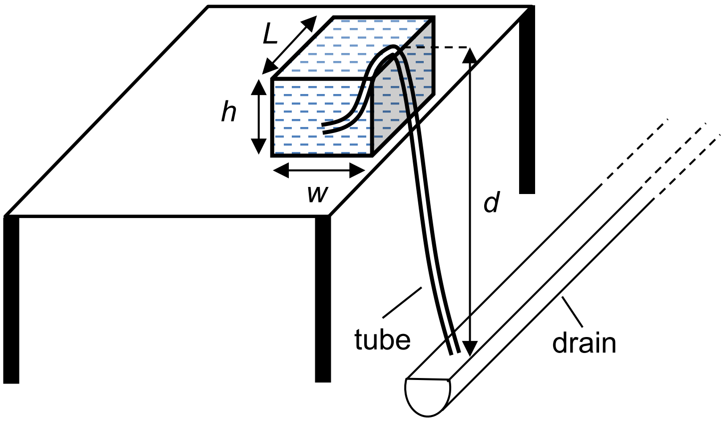

Fig. 12.1

(i) The student proposed that the time t taken to empty a fully filled tank is given by

$$t = \frac{L \times w \times h}{A\sqrt{2gd}}$$

where g is the acceleration of free fall.

Show that the equation is homogeneous.

[2]

(ii) State two ways why the equation in **(i)** may be physically incorrect, even though it is homogeneous.

1. ....

....

2. ....

.... [2]

(b) A wire of uniform circular cross-section has diameter d and length L. When a potential difference V is applied across the ends of the wire, a current I flows through the wire.

The resistivity ρ of the material of the wire is given by the expression

$$\rho = \frac{\pi d^2 V}{4LI}$$

In one particular experiment, the following measurements are made.

$d = (0.32 \pm 0.01)$ mm
$L = (50.0 \pm 0.1)$ cm
$V = (1.60 \pm 0.02)$ V
$I = (0.23 \pm 0.04)$ A

(i) Suggest an instrument that was used to measure d.

.... [1]

(ii) Calculate the value of ρ.

ρ = ... Ω m [2]

(iii) Calculate the actual uncertainty in ρ.

actual uncertainty in ρ = ... Ω m [2]

(iv) State the value of ρ and its actual uncertainty to the appropriate number of significant figures.

ρ = ... ± .... Ω m [1]

(v) Suggest an improvement that can be made to the experiment to reduce the percentage uncertainty in the value of ρ.

....

.... [1]

13 **(a)** Distinguish between *speed* and *velocity*.

....

.... [1]

(b) A ball is thrown from the top of a 50 m tall building at an angle 30° above the horizontal with an initial speed of 7.0 m s^{-1}. The ball lands at a horizontal distance *x* from the base of the building.

In the absence of air resistance, the path of the ball is shown in Fig. 13.1.

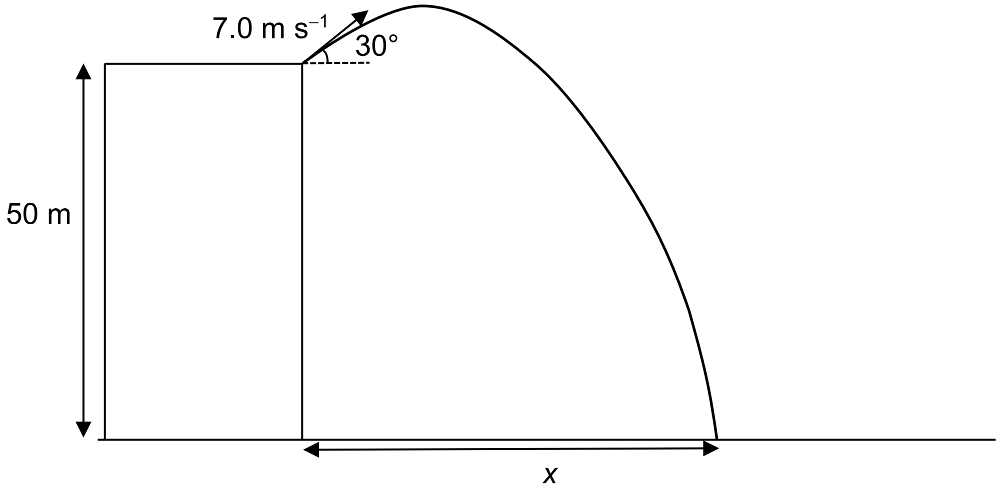

Fig. 13.1

(i) State the shape of the path.

.... [1]

(ii) Show that the time of flight is 3.57 s.

[1]

(iii) Calculate x.

x = ... m [2]

(iv) Determine the velocity of the ball at the instant just before it hits the ground.

magnitude of velocity = ... m s^{-1}

direction of velocity = ... [4]

(c) On Fig. 13.1, sketch the path of the ball if air resistance was present.

[2]

14 (a) State Newton's second law of motion.

....

....

....

.... [2]

(b) In a safety test on a sports car, a dummy is firmly restrained in its seat by means of seatbelts. The car suffers a head-on collision with a wall where both the car and the dummy are brought to rest from a speed of 30 m s^{-1} at an average deceleration of 80 m s^{-2}. The mass of the car is 1500 kg and the mass of the dummy is 80 kg.

(i) Calculate the magnitude of the change in momentum of the car and the dummy.

magnitude of change in momentum = ... N s [2]

(ii) Determine the duration of the collision.

duration of collision = ... s [2]

(iii) Using the principle of conservation of linear momentum, state and explain whether the linear momentum of the car and the dummy is conserved in this collision with the wall.

....

....

....

.... [2]

(iv) During the collision, the dummy's head of mass 3.0 kg stays firmly attached to its body. Calculate the average horizontal force exerted by the neck on the dummy's head.

average horizontal force = ... N [2]

(v) Professional race car drivers are usually fitted with a harness as shown in Fig. 14.1. The harness is shaped like a "U", with the back of the "U" set behind the back of the neck and its two arms lying flat along the top and over the driver's chest. The harness is supported by the shoulders and attached only to the helmet.

Fig. 14.1

Suggest, with a reason, how the harness helps to prevent injury to the neck of a driver in a head-on collision.

....

....

....

.... [2]

15 **(a)** Explain what is meant by the weight of an object.

....

.... [1]

(b) A light spring of force constant 14 N m^{-1} is attached to a fixed horizontal rod. A solid steel cube of mass 0.070 kg is hung from the end of the spring, and the spring-mass system is in equilibrium as shown in Fig. 15.1.

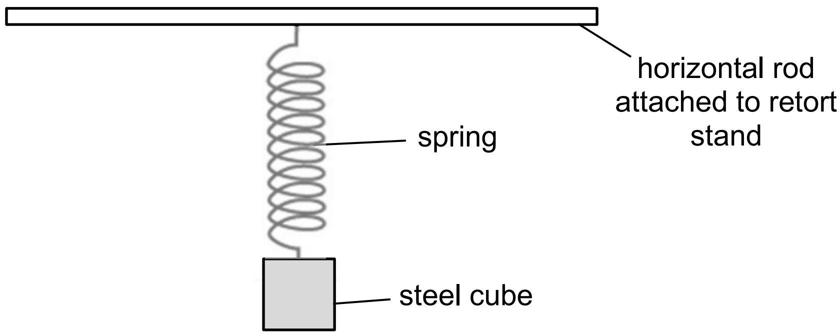

Fig 15.1

Show that the extension in the spring is 0.049 m.

[1]

(c) The spring-mass system is lowered into a beaker of water of density 1000 kg m^{-3} as shown in Fig. 15.2.
75% of the steel cube is submerged in the water.

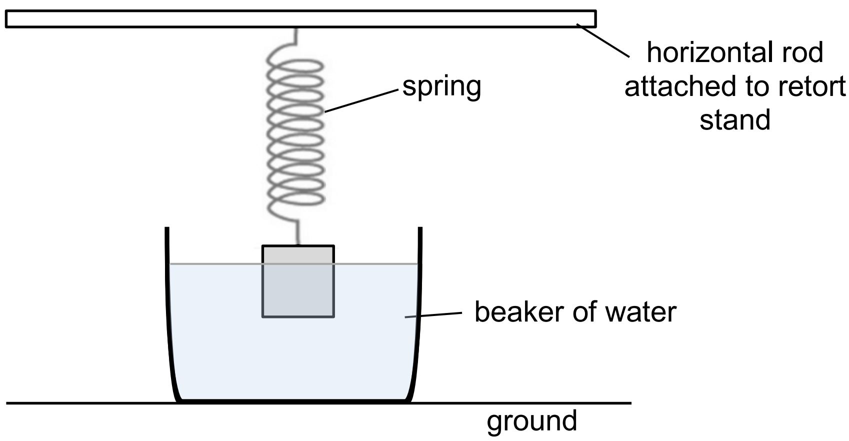

Fig. 15.2

(i) On Fig. 15.2, draw and label the forces acting on the steel cube. [3]

(ii) Calculate the upthrust acting on the steel cube.
[Density of steel = 7780 kg m^{-3}]

upthrust = ... N [3]

(iii) Hence, calculate the extension in the spring with the steel cube submerged.

extension = ... m [2]

(iv) An identical spring mass system is now lowered into a container of oil with 75% of the steel cube submerged.

State and explain in terms of forces whether the new extension in the spring is now longer or shorter than your answer in **(c)(iii)**.

....

....

....

.... [2]

16 **(a)** **(i)** Define *work*.

....

.... [1]

(ii) Hence, derive the equation

$$E_p = mgh,$$

for the change in gravitational potential energy of a mass m, when moved a vertical distance h upwards against a uniform gravitational field of field strength g.

[2]

(b) When a body of mass 400 g is hung from a light elastic spring of force constant 17.1 N m^{-1} suspended from a fixed point, it produces an extension of 23.0 cm.

(i) Calculate the elastic potential energy stored in the spring when it was extended by 23.0 cm.

elastic potential energy = ... J [2]

(ii) The 400 g body is supported and a 50 g mass is added to it. In this position, the combined mass is released and falls by a distance *h* before coming to a rest momentarily.

1. Determine the distance *h*.

h = ... m [3]

2. On the axes of Fig.16.1, sketch and label the variations with distance fallen of the elastic potential energy E_s stored in the spring and the gravitational potential energy E_p of the combined mass from the instant the combined mass is released from rest to the instant it comes to rest momentarily.

Take E_p to be zero at the position of release. No additional calculations are required.

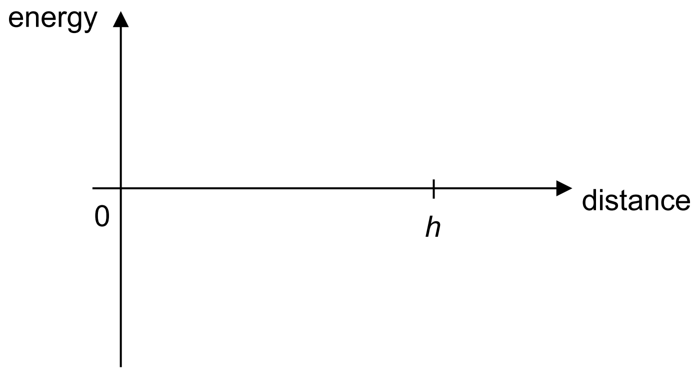

Fig. 16.1

[3]

17 Diffusion is the net movement of a substance from a region of higher concentration to a region of lower concentration. Molecular diffusion is, for example, the mechanism by which nutrients (such as amino acids or water molecules) are absorbed into the bloodstream from the digestive tract.

Without any external influence, steady state is reached when the concentration of the substance is uniform throughout the region. However, within the uniform gravitational field close to the surface of the Earth, the concentration of the substance varies with the height from the bottom of the region when steady state is reached.

The concentration of an unknown substance in a solution is measured. The variation with height h of the concentration n_h (number of molecules per cubic meter) is shown in Fig. 17.1.

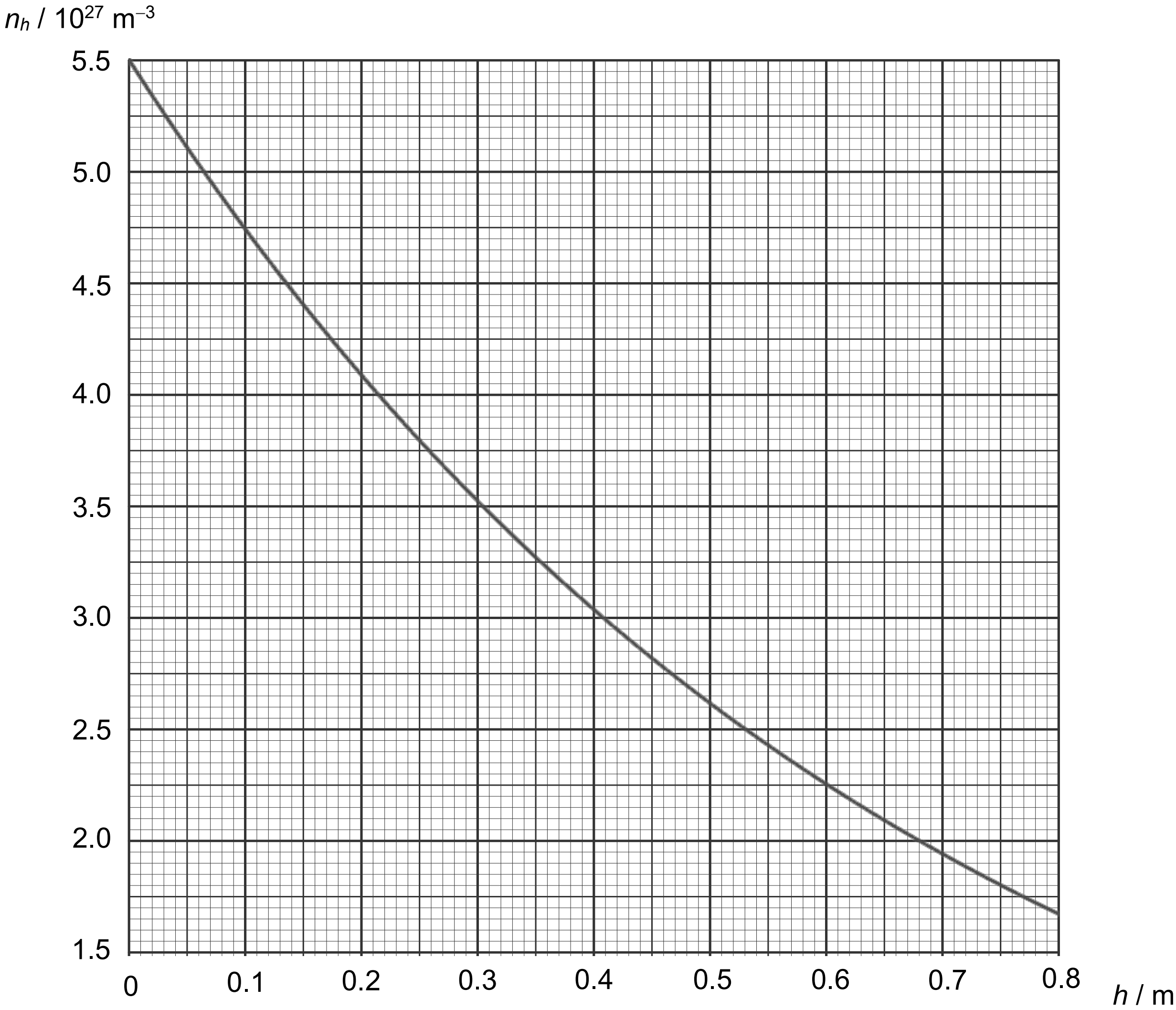

Fig. 17.1

(a) Describe, without any calculation, the variation with height of the concentration of the substance.

....

.... [2]

(b) Some corresponding values of h and $\ln n_h$ for the data in Fig. 17.1 are plotted on the graph of Fig. 17.2.

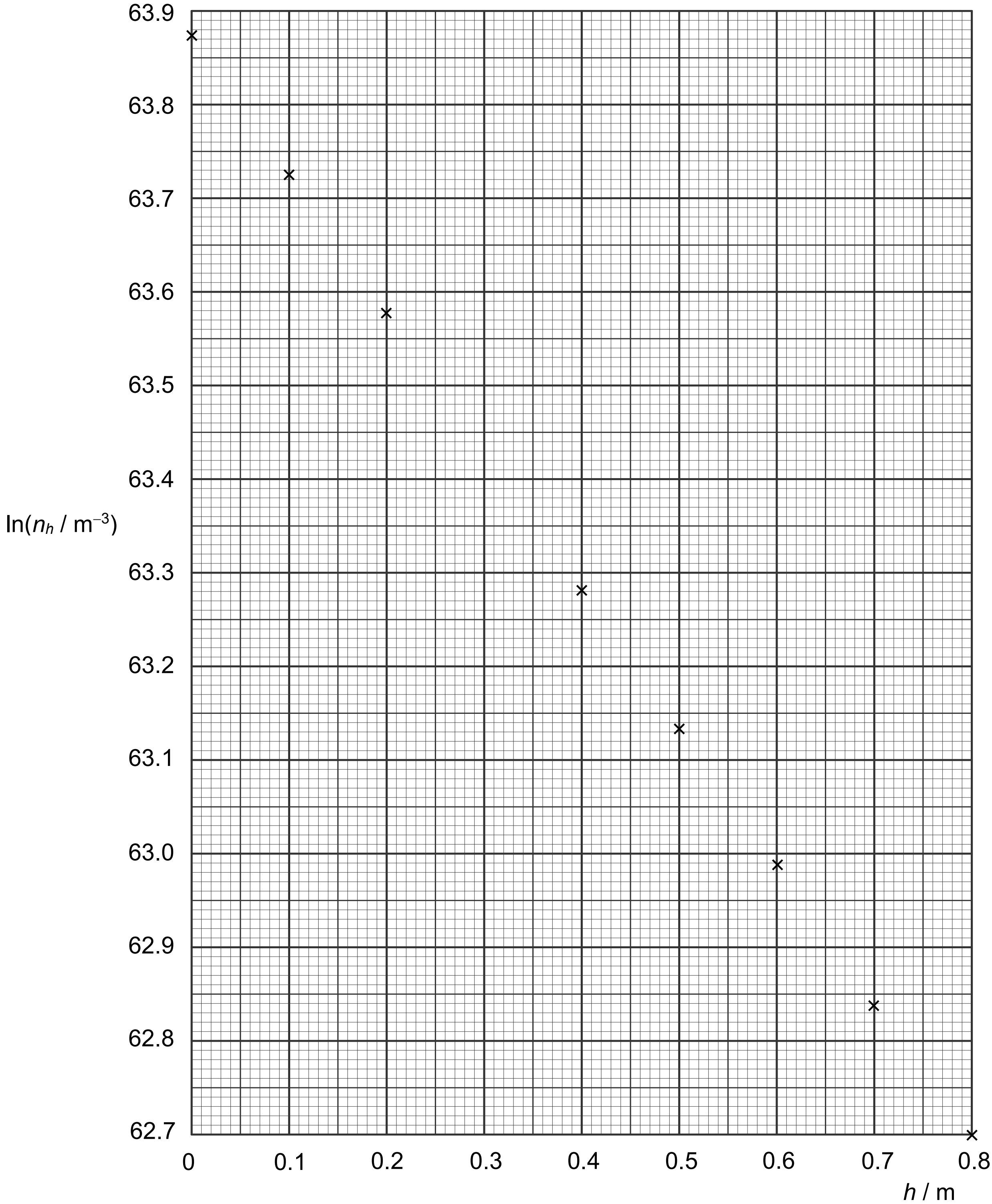

Fig. 17.2

(i) On Fig. 17.2,

1. plot the point corresponding to height $h = 0.3$ m, [1]

2. draw the best-fit line for all the plotted points. [1]

(ii) Determine the gradient of the line drawn in **(i) part 2**.

gradient = ... [2]

(c) It is proposed that the concentration n_h varies with height h according to the expression

$$n_h = n_0 e^{-\frac{mgh}{kT}},$$

where

h is the height at which the concentration is being measured,
n_h is the concentration at height h,
n_0 is a constant,
m is the mass of a molecule of the unknown substance,
$k = 1.38 \times 10^{-23}$ m^2 kg s^{-2} K^{-1} is the Boltzmann constant,
$T = 273$ K is the temperature of the solution.

(i) Suggest a possible physical meaning for n_0.

....

.... [1]

(ii) Explain why the graph of Fig. 17.2 supports this proposal.

....

....

.... [2]

(iii) Using your answer to **(b) (ii)**, determine the mass *m* of a molecule of the unknown substance.

m = ... kg [3]