Name: ______________________ (   )   **CT Group: 25S0** ____

RAFFLES INSTITUTION

2024 YEAR 5 Timed Practice

H2 PHYSICS

9749

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Name, Index Number and CT Group in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a 2B pencil for any diagrams or graphs.

The use of an approved scientific calculator is expected, where appropriate.
Answer **all** questions.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 10
2	/ 10
3	/ 9
4	/ 9
5	/ 7
6	/ 9
7	/ 8
8	/ 10
9	/ 8
Deductions	
Total	/ 80

There are **20** printed pages, inclusive of the cover page, in this booklet.

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-Gm/r$
temperature	T/K	=	$T/°\text{C} + 273.15$
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t = \pm \omega \sqrt{x_0^2 - x^2}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$\dfrac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\dfrac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\dfrac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\ln 2 / t_{1/2}$

1 **(a)** Fig. 1.1 shows the apparatus used in an experiment to determine the specific heat capacity c of a metal block of mass m.

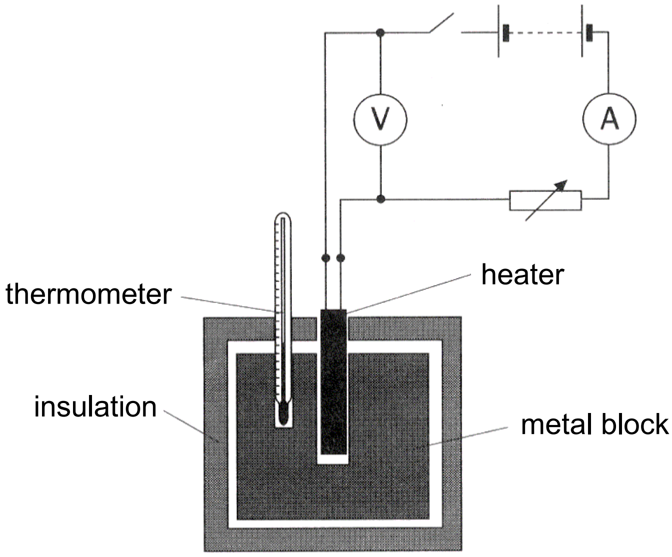

Fig. 1.1

The current I in the heater and the voltage V across it are measured. The initial temperature T_1 of the block and its temperature T_2 after the heater has been switched on for a period of time t are noted.

The measurements, with their actual uncertainties, are shown in Fig. 1.2.

m / kg	I / A	V / V	T_1 / °C	T_2 / °C	t / s
0.764 ± 0.001	3.80 ± 0.06	12.00 ± 0.08	25.4 ± 0.1	35.7 ± 0.1	60.0 ± 0.1

Fig. 1.2

The specific heat capacity c may be determined using the equation:

$$IVt = mc(T_2 - T_1).$$

(i) Determine the percentage uncertainty, to two significant figures, of the rise in temperature ($T_2 - T_1$).

percentage uncertainty = ... % [2]

(ii) Calculate the actual uncertainty in c.

actual uncertainty = ... $\text{J kg}^{-1}\text{ K}^{-1}$ [4]

(iii) State the value of c and its actual uncertainty to an appropriate number of significant figures.

c = ... ± .... $\text{J kg}^{-1}\text{ K}^{-1}$ [1]

(iv) Suggest one way, apart from changing the measuring instruments, in which the uncertainty of the specific heat capacity can be reduced.

....

.... [1]

(b) The drag coefficient C_D of a car moving with speed v through air of density ρ is given by:

$$C_D = \frac{2F}{A\rho v^2}$$

where F is the drag force exerted on the car and A is the maximum cross-sectional area of the car perpendicular to the direction of travel.

Show that C_D is a dimensionless constant.

[2]

[Total: 10]

2 During a football match, a goalkeeper released a ball from rest from a height of 1.10 m above ground.

(a) Show that the velocity v_1 of the ball just before it hits the ground is 4.65 m s^{-1}. Air resistance is negligible.

[1]

(b) Just before the ball hits the ground, the goalkeeper kicks the ball such that it moves off with a velocity v_R of 25.0 m s^{-1} at an angle of 40° above the horizontal. Air resistance is negligible.

(i) Sketch a labelled vector diagram to show the velocity v_1, the change in velocity Δv of the ball and the velocity v_R.

[1]

(ii) Determine the magnitude and direction of Δv.

magnitude of Δv = ... m s^{-1}

direction of Δv = ... [3]

(iii) Calculate the horizontal range of the ball.

horizontal range = ... m [3]

(c) State and explain how, in practice, the actual horizontal range of the ball might differ from your answer in **(b)(iii)**.

....

....

....

.... [2]

[Total: 10]

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

....

....

....

.... [2]

(b) A helicopter with two rotors carries a load of mass 3.7×10^3 kg and is accelerating vertically upwards at 0.39 m s^{-2} as shown in Fig. 3.1.

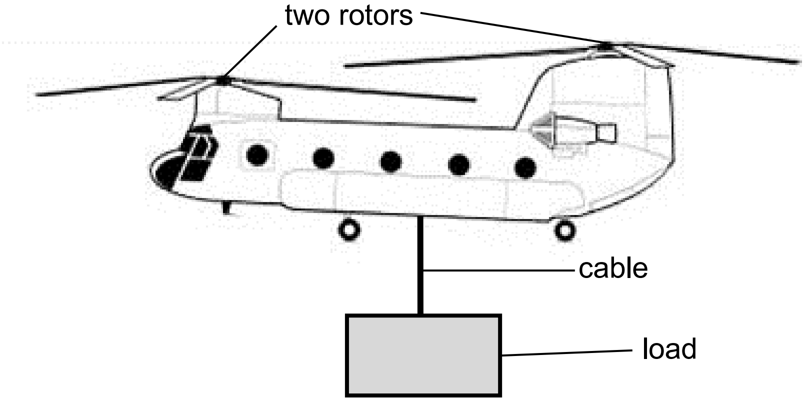

Fig. 3.1

(i) Calculate the tension in the cable.

tension = ... N [2]

(ii) The length of each rotor blade is 9.0 m. When the rotors are turning, each of them pushes a cylindrical column of air downwards at a velocity v.

The two rotors generate a combined total upward force of 1.5×10^5 N. The density of air is 1.3 kg m^{-3}.

Determine the value of v. Explain your working.

Ignore the effects of the rotor blades overlapping.

v = ... m s^{-1} [4]

(iii) Suggest why the ability of a helicopter to fly decreases with increasing altitude.

....

.... [1]

[Total: 9]

4 A sphere A of mass 0.250 kg travels at a speed of 30.0 m s^{-1} along the x-axis and collides with a sphere B of mass 0.600 kg which is initially at rest. After collision, sphere A moves off with a speed of 15.0 m s^{-1} at an angle of 30.0° to the x-axis, while sphere B moves off with a speed v_B at an angle of θ to the x-axis as shown in Fig. 4.1.

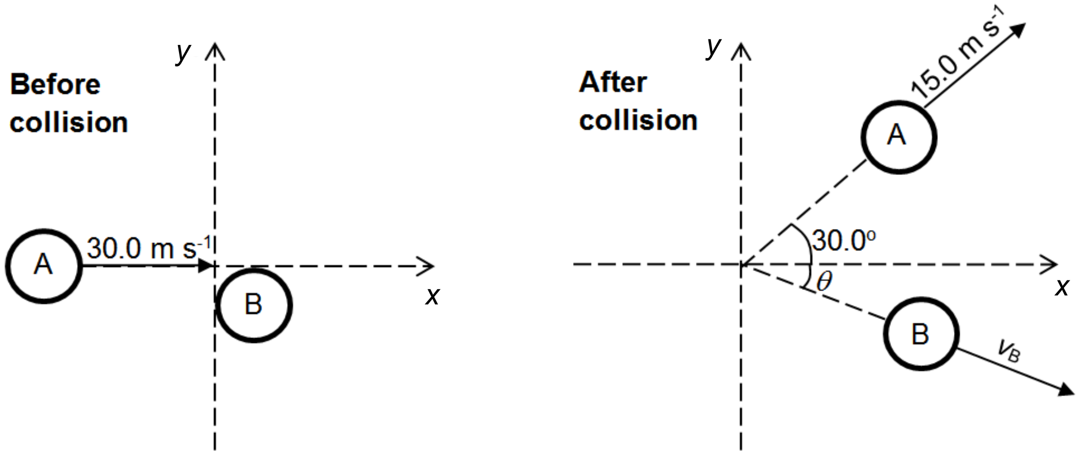

Fig. 4.1

(a) By considering the conservation of linear momentum along the y-axis, show that

$$v_B \sin\theta = 3.13 \text{ m s}^{-1}.$$

[1]

(b) By considering the conservation of linear momentum along the x-axis, show that θ is 23.8°.

[2]

(c) Calculate the speed v_B.

v_B = ... m s^{-1} [1]

(d) Sketch a labelled vector diagram which shows the relationship between the total momentum p_T before collision and the momenta p_A and p_B of the spheres A and B respectively after collision. Include the angles between the momenta in your diagram.

[2]

(e) Determine, with appropriate calculations, whether the collision is elastic.

....

.... [3]

[Total: 9]

5 One end of a light inextensible cord is fixed at the ceiling. The other end is attached to a uniform ball of weight 60 N. The system is at rest as shown in Fig. 5.1.

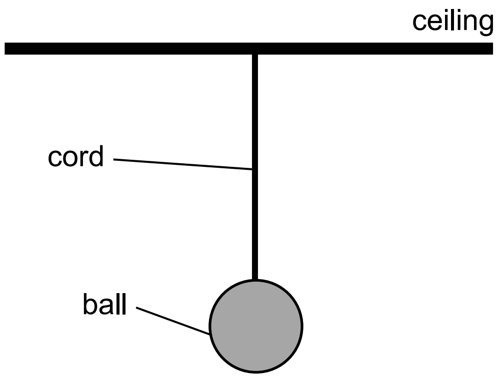

Fig. 5.1

(a) A constant force F of 40 N at an acute angle θ to the vertical is applied to the ball. Both the lines of action of the tension of the cord and F act through the centre of gravity of the ball. At equilibrium, the cord is tilted at an angle of 30° to the vertical as shown in Fig. 5.2.

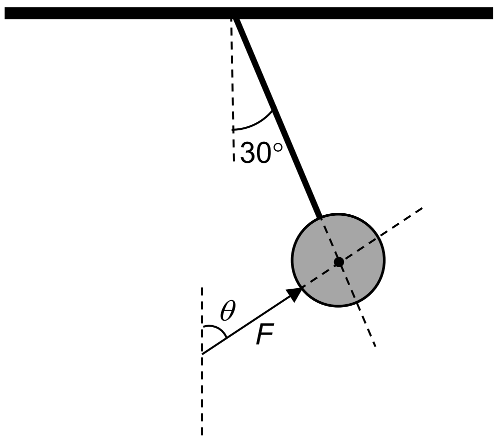

Fig. 5.2 (not to scale)

(i) Sketch a labelled vector triangle of the forces acting on the ball when the ball is in equilibrium.

Explain how your diagram shows that the ball is in equilibrium.

....

.... [2]

(ii) Hence, determine the angle θ.

θ = ... ° [2]

(iii) Determine the tension in the cord.

tension = ... N [1]

(b) The ball is now attached to another identical cord at its bottom and the lower cord is pulled downwards with a slowly increasing force as shown in Fig. 5.3.

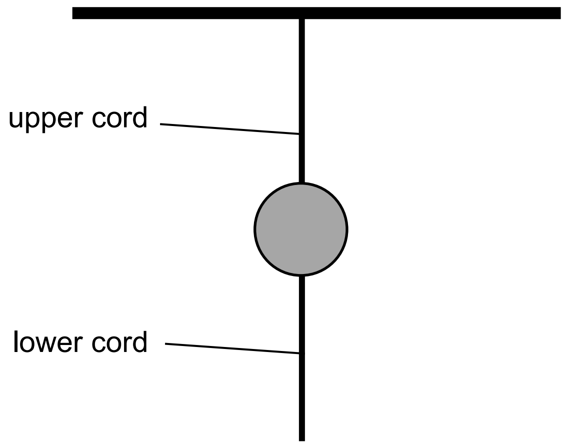

Fig. 5.3

State and explain which cord will break first.

....

....

....

.... [2]

[Total: 7]

6 An artist is setting up an art installation consisting of a uniform large cube of mass 50 kg and side length 3.0 m. To put it in position, the artist ties a rope to one corner of the cube and pulls on it, pivoting the cube at the bottom corner B.

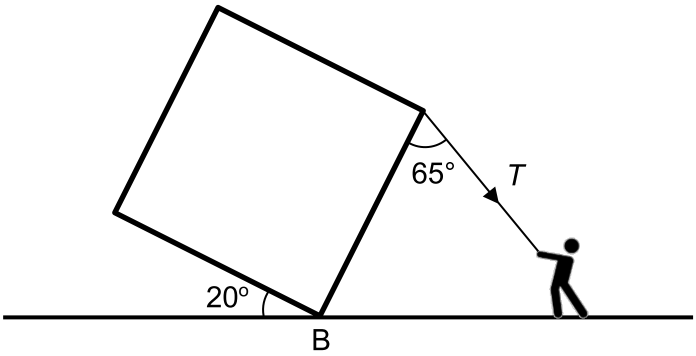

Fig. 6.1

When the cube is tilted by 20°, the artist decides to hold the cube in place at rest, in the position shown above. The rope makes an angle of 65° to the side of the cube, and has a tension T, as shown in Fig. 6.1.

(a) Determine the moment due to the weight of the cube about point B.

moment = ... N m [3]

(b) Determine the tension T in the rope.

T = ... N [2]

(c) (i) Draw an arrow on Fig. 6.1 to indicate the direction of the frictional force acting on the cube at point B. Label the frictional force f.
Explain your answer.

....

....

....

.... [3]

(ii) Determine the magnitude of the frictional force at point B.

frictional force = ... N [1]

[Total: 9]

7 Fig. 7.1 shows a block attached to a horizontal spring of force constant k. The block is resting on a smooth floor and the other end of the spring is fixed to a vertical wall. Initially the spring is unstretched.

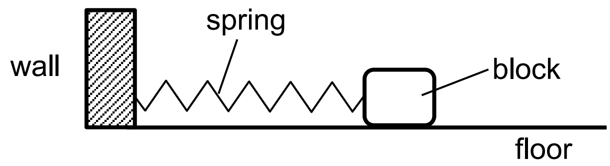

Fig. 7.1

When a force F is applied on the block horizontally to the right, the extension of the spring is x. Fig. 7.2 shows the variation with extension x of F.

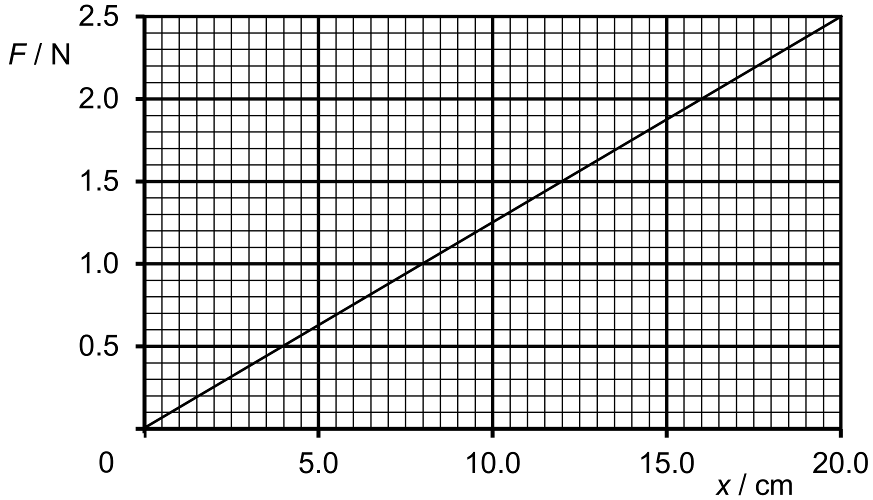

Fig. 7.2

(a) Determine the force constant k.

k = ... N m^{-1} [2]

(b) Calculate the work done by F in stretching the spring from x = 0 to x = 20.0 cm.

work done = ... J [2]

(c) The block is released from rest when $x = 20.0$ cm.

(i) Determine the kinetic energy of the block at the instant when x is 10.0 cm.

kinetic energy = ... J [2]

(ii) Sketch, on the axes of Fig. 7.3, the variation with x of

1. the elastic potential energy of the spring (label this line P)

2. the kinetic energy of the block (label this line K).

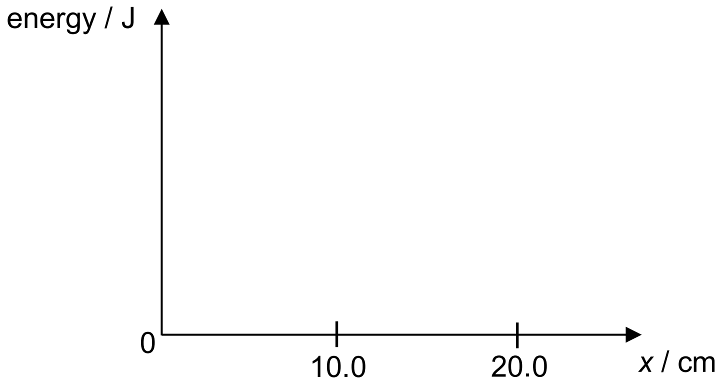

Fig. 7.3

[2]

[Total: 8]

8 A steel sphere of mass 0.29 kg is suspended in equilibrium from a vertical spring. The centre of the sphere is 19.8 cm from the top of the spring, as shown in Fig. 8.1.

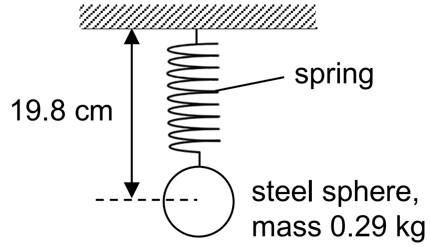

Fig. 8.1

The sphere is now set in motion so that it is moving in a horizontal circle at constant speed, as shown in Fig. 8.2.

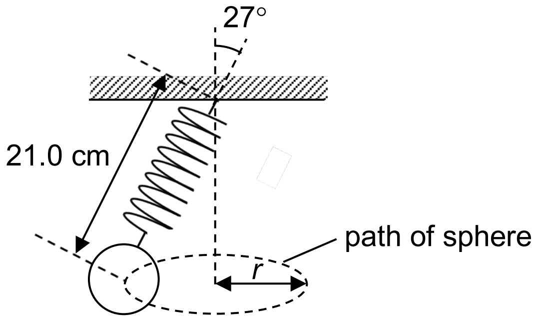

Fig. 8.2

The distance from the centre of the sphere to the top of the spring is now 21.0 cm.

(a) Explain, with reference to the forces acting on the sphere, why the length of the spring in Fig. 8.2 is greater than in Fig. 8.1.

....

....

....

....

....

.... [3]

(b) The angle between the axis of the spring and the vertical is 27°.

(i) Show that the radius r of the circle is 9.5 cm.

[1]

(ii) Calculate the tension in the spring.

tension = ... N [2]

(c) **(i)** Determine the centripetal acceleration of the sphere.

centripetal acceleration = ... m s^{-2} [2]

(ii) Calculate the period of the circular motion of the sphere.

period = ... s [2]

[Total: 10]

9 Fig. 9.1 shows a type of amusement park ride which puts the passengers through a vertical circular motion at varying speed. Passengers are seated on the platform which remains horizontal while the arm connected to it swings without friction about a pivot in a vertical circle. A counter-weight of mass 3000 kg is connected to the other end of the arm. The mass of the arm is negligible.

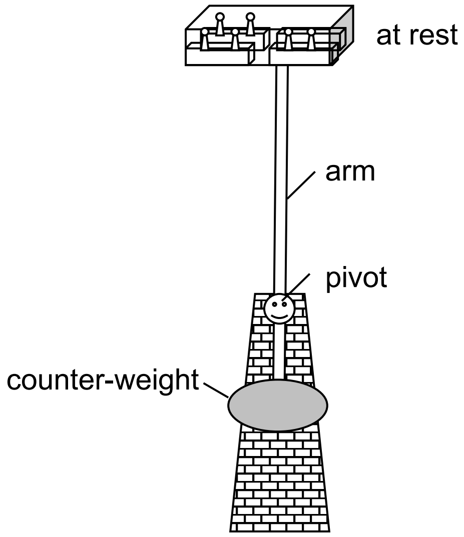

Fig. 9.1(a)

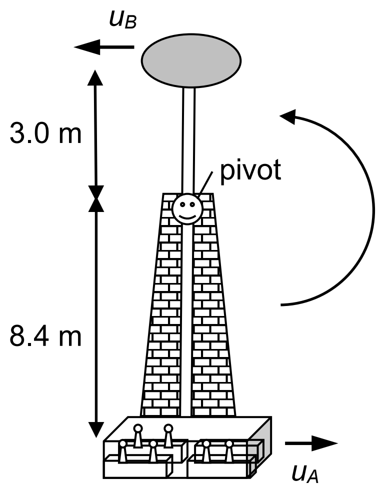

Fig. 9.1(b)

The platform is at rest at the top before it swings anti-clockwise from the position shown in Fig. 9.1(a) to that shown in Fig. 9.1(b). When the platform is at the position shown in Fig. 9.1(b), it has a speed u_A while the counter-weight has a speed u_B. The mass of the fully loaded platform is 2000 kg.

(a) Show that $\frac{u_A}{u_B} = 2.8$. Explain your working.

[1]

(b) **(i)** By considering the platform moving from the position shown in Fig. 9.1(a) to the position shown in Fig. 9.1(b), determine the value of u_A.

u_A = ... m s^{-1} [3]

(ii) Calculate the centripetal force acting on the platform at the position shown in Fig. 9.1(b).

centripetal force = ... N [2]

(iii) A passenger of mass 70 kg is seated on the platform when it is at the position as shown in Fig. 9.1(b).

Determine the normal contact force acting on the passenger.

normal contact force = ... N [2]

[Total: 8]