Centre Number	Index Number	Name	Class
S3016			

RAFFLES INSTITUTION
2019 Preliminary Examination

PHYSICS
Higher 2

9749/03

Paper 3 Longer Structured Questions

27 September 2019
2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your index number, name and class in the spaces at the top of this page.
Write in dark blue or black pen in the spaces provided in this booklet.
You may use a pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer **one** question only and **circle the question number** on the cover page.

You are advised to spend one and half hours on Section A and half an hour on Section B.

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

* **This booklet only contains Section B.**

For Examiner's Use		
Section B (circle 1 question)	**8**	/ 20
	9	/ 20

This document consists of **8** printed pages.

Section B

Answer **one** question from this Section in the spaces provided.

8 **(a)** State Newton's Second Law.

.....

.....

..... [2]

(b) A toy truck of mass 1.0 kg is moving in a straight line on a horizontal surface as shown in Fig. 8.1. The toy truck has a cargo compartment at the back with an open top.

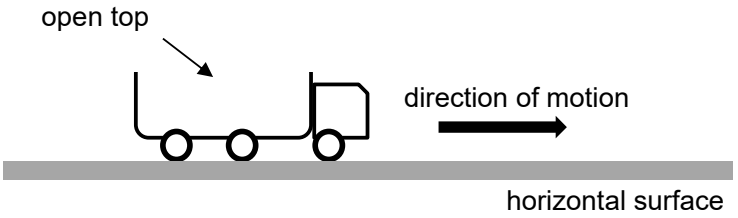

Fig. 8.1

Air resistance is negligible.

(i) If the engine of the toy truck delivers a constant driving force of 0.0050 N, calculate the impulse of the driving force for a duration of 30 s.

impulse = ... N s [1]

(ii) The toy truck was moving with a speed of 0.20 m s^{-1} when it started to rain. The rain droplets fall vertically and collect in the cargo compartment.

Show that the horizontal momentum of the truck and the rain droplets collected 30 s after the rain started is 0.35 N s.

horizontal momentum = ... N s [1]

(iii) The rain droplets collect in the cargo compartment at a rate of 0.0325 kg s^{-1}.

1. Calculate the total mass of the toy truck and the droplets collected at the end of the 30 s duration.

total mass = ... kg [1]

2. Using your answer in **(b)(ii)**, show that the final speed of the truck is 0.177 m s^{-1}.

[1]

3. Hence, state and explain the direction of the average acceleration of the toy truck.

.....

.....

..... [2]

4. By considering the forces acting on the toy truck, explain why it slows down despite a forward driving force.

.....

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.....

.....

..... [3]

(c) An oscillating system, whereby a sphere is attached to the top of a spring, is fitted into the cargo compartment of the toy truck, as shown in Fig. 8.2.

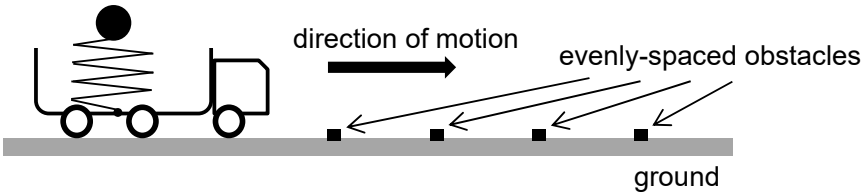

Fig. 8.2

The toy truck moves over evenly-spaced obstacles placed on the ground, causing the sphere to oscillate in the vertical direction.

The mass m of the sphere is 0.10 kg. The force constant k of the spring is 2.0 N m^{-1}.

(i) The equilibrium position of the sphere is defined as the position where the sphere experiences no net force.

1. Write down an equation for the net force acting on the sphere in terms of its vertical displacement x from the equilibrium position and the force constant k of the spring.

[1]

2. Using Newton's Second Law, show that the acceleration a of the sphere and its displacement x from the equilibrium position are related by

$$a = -\omega^2 x,$$

where

$$\omega = \sqrt{\frac{k}{m}}$$

is called the angular frequency of the oscillation.

[1]

3. Explain the meaning of the negative sign in the equation $a = -\omega^2 x$.

[1]

(ii) Calculate the natural frequency of the oscillating system.

natural frequency = ... Hz [2]

(iii) When the toy truck is moving across the obstacles at a constant velocity of 5.0 m s^{-1}, the sphere oscillates with maximum amplitude.

Calculate the distance between consecutive obstacles.

distance = ... m [2]

(iv) As the toy truck continues to move over the obstacle at the same speed, it starts to drizzle and the sphere absorbs rainwater.

State and explain the effect of the absorbed rainwater on the oscillation of the system.

.....

.....

.....

..... [2]

[Total: 20]

9 **(a)** Explain what is meant by a *photon*.

.....

..... [1]

(b) **(i)** Describe the appearance of a visible line emission spectrum.

.....

.....

..... [2]

(ii) Explain how line spectra, together with the concept of a photon, provide evidence for discrete energy levels in isolated atoms.

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..... [3]

(c) Some electron energy levels of the hydrogen atom are illustrated in Fig. 9.1.

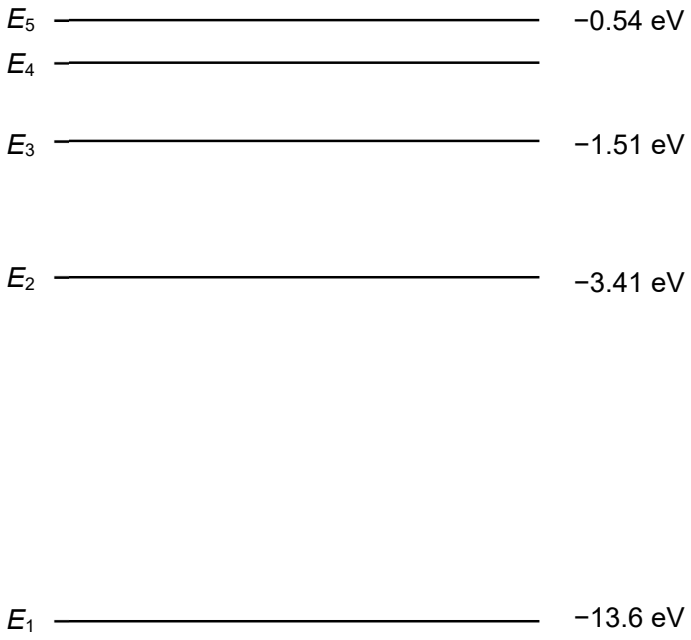

Fig. 9.1 (not to scale)

(i) By considering the transitions between these energy levels, state how many spectral emission lines might be produced by transitions among these levels.

number of lines = ... [1]

The wavelength of a photon produced by the transition from energy level E_4 to E_1 is 97.5 nm.

(ii) State the type of electromagnetic radiation of the photon.

..... [1]

(iii) Determine the energy level E_4 in electronvolts.

energy = ... eV [2]

(iv) Show that the shortest possible wavelength of the photons that can be emitted from a hydrogen atom is 91.4 nm.

[2]

(d) The radiation emitted from hydrogen atoms is incident on the surface of a sheet of gold.

The stopping potential for photoelectrons emitted from the gold surface is 8.13 V.

(i) Calculate the work function of the metal surface in electronvolts.

work function = ... eV [2]

(ii) Calculate the momentum of the most energetic electrons emitted from the gold surface.

momentum = ... N s [2]

(iii) Hence, determine the de Broglie's wavelength of the electrons in **(ii)**.

wavelength = ... m [2]

(iv) The speed of one of the photoelectrons emitted is measured to be 1.2×10^6 m s^{-1} to an accuracy of 0.0025 %.

Calculate the minimum uncertainty in the position of this photoelectron.

minimum uncertainty in position = ... m [2]

[Total: 20]

End of Paper 3 Section B