LA SALLE COLLEGE

F5

F5 PHYSICS

Final Examination 2014 to 2015

8:10 am – 9:55 am (1¾ hours)

Question-Answer Book (Section B & Section C)

This paper must be answered in English

Exam Number			

	Marker's Use only
Section A	**Marks**
Section B Question No.	**Marks**
1	
2	
3	
4	
Section C Question No.	**Marks**
5	
6	
7	

Total	

Instructions for Section B and Section C

1. After the announcement of the start of the examination, you should first write your Exam Number in the space provided on the cover page and every odd-numbered page of this Question-Answer Book.

2. Refer to the general instruction on the cover page of the Question Paper for Section A.

3. Answer ALL questions.

4. Write your answers of Section B and Section C in the spaces provided in this Question-Answer Book.

5. Unless otherwise specified, numerical answers should be either exact or correct to 3 significant figures.

6. Supplementary answer sheets will be supplied on request. Write your Examination Number on each sheet and insert them inside this book.

7. Take $g = 9.81$ m s^{-2} and speed of light $= 3 \times 10^8$ ms^{-1}.

8. The last two pages of this Question-Answer Book contain a list of data, formulae and relationships which you may find useful.

SECTION B: Short Questions (28 marks)

Answer ALL questions in this section and write your answers in the space provided.

Question No.	1	2	3	4
Marks	7	7	7	7

1. Two long and thin aluminum rods are suspended from a ceiling by four identical strings each of length 0.8 m. When equal currents pass through the rods in opposite directions, the rods repel and the angle between the strings is 10°, as shown in Figure 1.1.

Figure 1.1

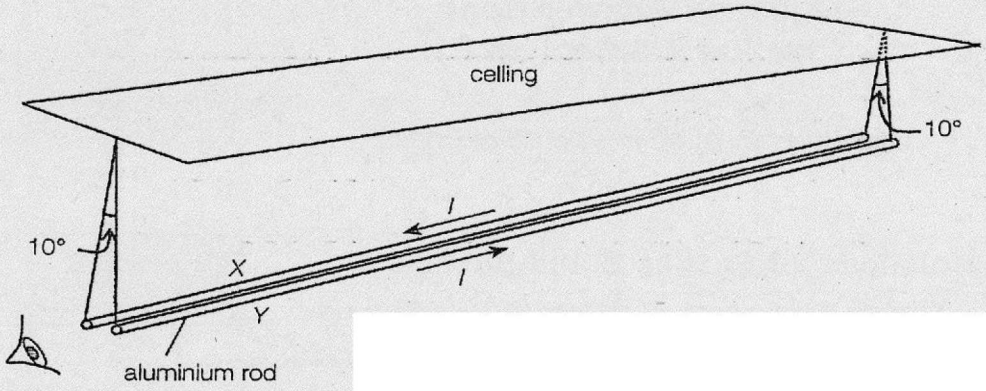


Figure 1.2 represents the cross-sections of the rods *X* and *Y*, looking from the left.

(a) (i) Sketch the magnetic field pattern due to the current in *X* inside the dotted square. Show at least 5 field lines.

(ii) At the position of rod *Y*, mark the direction of the magnetic field of the current in *X*. Indicate the direction of the magnetic force acting on *Y* due to the current in *X*.

(3 marks)

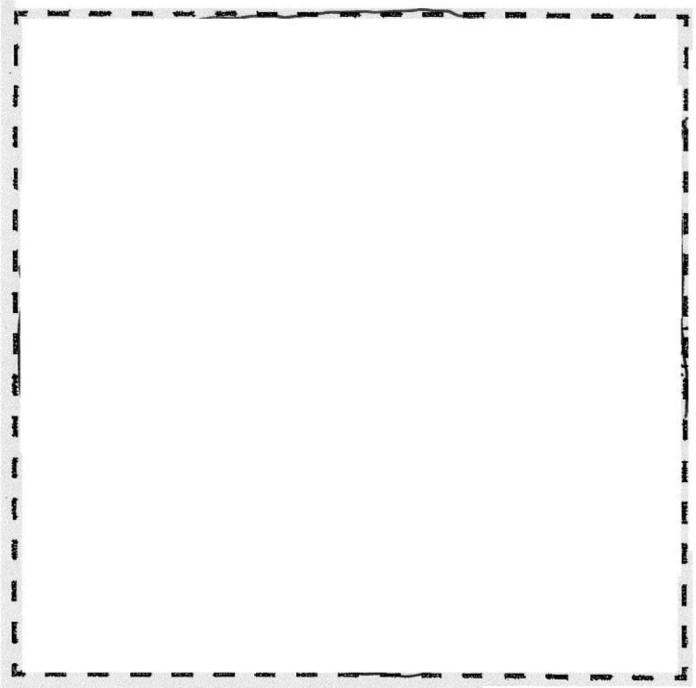


Figure 1.2

Exam Number			

(b) Given that the mass per unit length of the rods is 0.011 kg m^{-1}, calculate the current *I*.
(Take g = 9.81ms^{-2}.) (4 marks)

2. (a) (i) Calculate the number of air molecules in 1 cm^3 of air under standard atmospheric pressure of 1.01 x 10^5 Pa and at a temperature of 25°C.

Given: The molar mass of air $= 2.88 \times 10^{-2}$ kg. (2 marks)

(ii) Determine the r.m.s. speed of air molecules under the conditions in (a) (i). (2 marks)

(b) In outer space there is only a trace amount of hydrogen atoms, on average only 1 hydrogen atom in 1 cm^3. It is estimated that the r.m.s. speed of hydrogen atoms in outer space is 260 m s^{-1}. Estimate the pressure in outer space.

Given: The molar mass of hydrogen $= 1.00 \times 10^{-3}$ kg

The Avogadro's number $N_A = 6.02 \times 10^{23}$

(3 marks)

Exam Number			

3. A desk lamp (Figure 3.1) is illustrated as shown in Figure 3.2. The lamp consists of uniform aluminum rods *AB* and *BC*, each of length 0.30 m, and a uniform circular steel base of diameter 0.20 m. *P* and *Q* are two end points of a diameter of the base. The inclinations of the rods can be adjusted by the joints at *A* and *B*, and the lamp is placed so that the weight of the bulb is always below *C*. The weight of each of the rods *AB* and *BC* is 3 N and the weight of the bulb with the shade is 6 N.

Figure 3.1

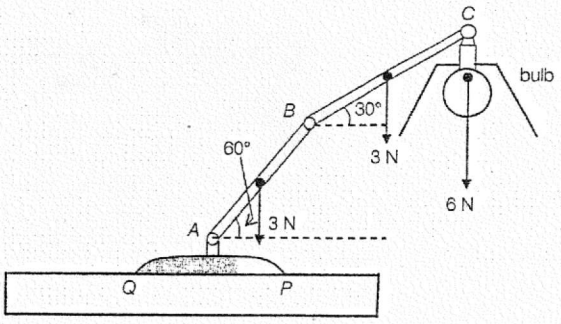


Figure 3.2

(a) The lamp is placed on a horizontal desk. When the lamp is adjusted in the position shown in Figure 3.2, it just begins to topple.

(i) State about which point that the lamp will just topple. (1 mark)

(ii) Take moment about the point found in (a) (i), and find the weight of the circular base. (3 marks)

(b) What should be the minimum weight of the base if the lamp will not topple for all possible orientations of the rods when keeping the bulb vertical and below *C*? (3 marks)

4. The space lab module Tiangong 1 is moving in a circular orbit 350 km above Earth's surface. On 1 November 2011, Shenzhou 8 was launched; it successfully docked with Tiangong 1 which was moving in the same direction on 3 November 2011 (Figure 4). This unmanned docking of a spacecraft with a space lab module was a breakthrough in China's space programme.

Figure 4

Shenzhou 8 spacecraft (left) and Tiangong 1 space module about to dock

Given that the acceleration due to gravity on Earth's surface is 9.81 ms^{-2}, and the radius of Earth is approximately 6 370 km.

(a) Calculate the gravitational field strength at the orbit of Tiangong 1. (2 marks)

(b) Tiangong 1 has a mass of 8 000 kg. Find its kinetic energy in the orbit. (3 marks)

Exam Number			

(c) Find the period of Tiangong 1 orbiting around the Earth. (1 mark)

(d) Explain briefly why it is impossible for docking to occur if the two spacecrafts are moving in opposite directions in the same orbit. (1 mark)

***** End of Section B *****

C: Long Questions (42 marks)

Answer ALL questions in this section and write your answers in the space provided.

Question No.	5	6	7
Marks	14	14	14

5.

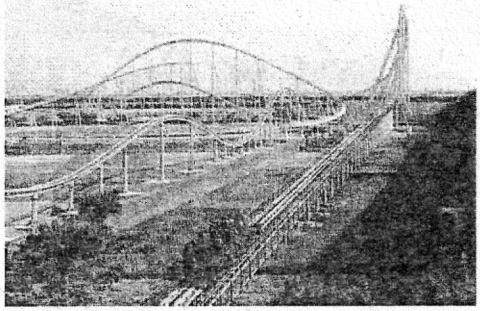


Figure 5.1

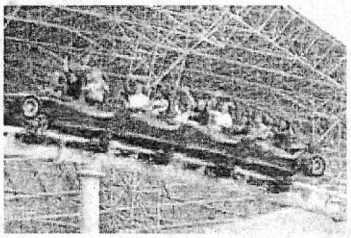


Figure 5.2

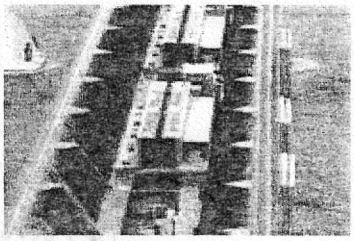


Figure 5.3

Formula Rossa at Ferrai World Abu Dhabi, United Arab Emirates is the world's fastest roller coaster; the total track length of Formula Rossa is 2.07 km (Figure 5.1). A hydraulic launch system is used to speed up the cart (Figure 5.2) of Formula Rossa along a horizontal track from rest to a top speed of 240 km h^{-1} in approximately 4.9 seconds to create a sensation as a Formula One driver to the passengers, the cart is then ascending to the highest point of a hill, which is 53 m above ground level.

In the "uphill" motion, the cart is gradually slowed down with magnetic brakes, the magnetic brakes is operating with a copper plate beneath the cart and moving between pairs of strong magnets mounted on the track (Figure 5.3).

(a) If the mass of the fully loaded cart is 3 000 kg, estimate the minimum power output of the hydraulic launch system. (3 marks)

(b) Assume that the cart reaches the top of the hill with a speed of 3 ms^{-1}; estimate the work done against the magnetic braking system. Take g = 9.81 m s^{-2} (2 marks)

Exam Number			

(c) Explain why the magnetic brakes can slow down the cart without any contact with it. (3 marks)

(d) State two advantages of using the magnetic brakes over traditional friction brakes. (2 marks)

(e) After passing through the top of the hill at a speed of 3 ms^{-1}, the cart is unpowered and starts the first and the biggest drop of height of 51.5 m. If 15 % of the mechanical energy is used to do work against friction between the cart and the track, estimate the speed of the cart when it reaches the lowest point in the first drop. (2 marks)

(f) If the travelling distance of the cart in the first drop is 400 m, find the average friction between the cart and the track. (2 marks)

6. An electromagnetic rail gun (Figure 6.1) is a powerful weapon, instead of using gunpowder as a propellant; it launches the projectiles by an extremely strong magnetic field (Figure 6.2).

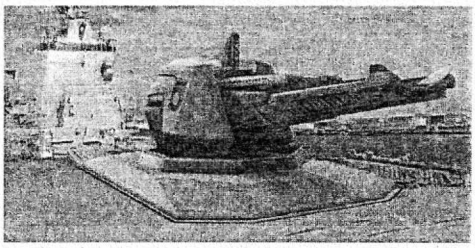


Figure 6.1

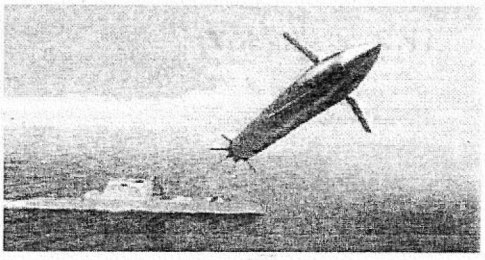
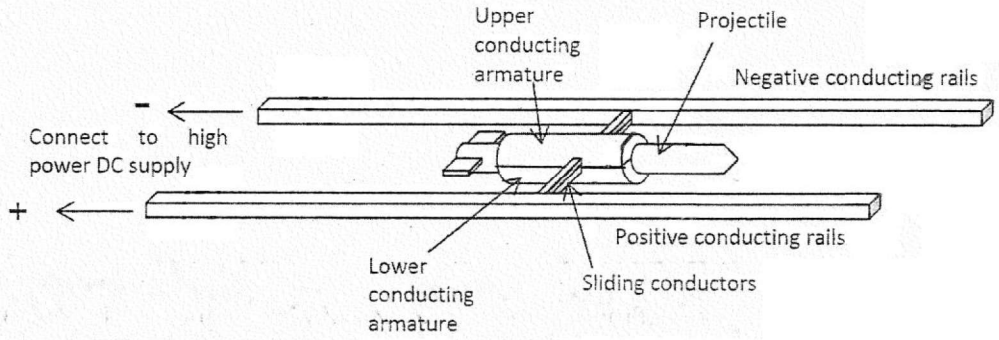


Figure 6.2

Figure 6.3 shows the schematic diagram of the electromagnetic rail gun. A projectile with conducting armatures is set onto the parallel conducting rails; it forms a complete electric circuit with a high voltage d.c. power supply. When a large current flows through the rail gun, a huge magnetic force will act on the projectile and accelerate the projectile until it leaves the rails and breaks the circuit. A projectile in the rail gun can be accelerated up to **MACH 7** (i.e. 7 times the speed of sound in air) when a huge current of a million amperes is used.

Figure 6.3



(a) On Fig. 6.3, indicate the direction of

(i) the magnetic field around the rails by drawing a field line with arrow for each rail,

(ii) the current across the projectile,

(iii) the magnetic force acting on the projectile, (2 marks)

(b) It is difficult to keep the rails stationary during firing because a pair of large magnetic forces acts between the parallel rails.

(i) Do these forces push the parallel rails together or pull them apart? (1 mark)

(ii) Assume the current flowing through the rails is 1×10^6 A and the parallel rails are 1 m apart. Estimate the magnitude of the magnetic force per unit length between the rails. (2 marks)

Exam Number			

(c) A 3.2 kg projectile is fired horizontally with the speed of MACH 7 from an electromagnetic rail gun in a Zumwalt-class destroyer. The length of the rail to accelerate the projectile from rest to the speed of MACH 7 is 5 m. (Speed of sound in air = 330 ms^{-1})

(i) Find the energy output of the gun to fire the projectile. (2 marks)

(ii) Find the average output power of the rail gun to fire the projectile. (3 marks)

(d) A projectile is fired with an angle with the horizontal with the speed of MACH 7 (Figure 6.2).

(i) Find the maximum horizontal range of the projectile. Neglect the length of the rail gun and air resistance. (2 marks)

(ii) Find the time elapsed in (d) (i). (2 marks)

7. Figure 7.1 shows a safety device in a domestic circuit known as a 'Residual Current Circuit Breaker' (RCCB) and Figure 7.2 shows the circuit diagram of its essential components. The live and neutral wires form two coils mounted on the iron ring. In normal operation, the live wire and neutral wire carry the same current in opposite directions and balance each other, the sensing coil does not experience magnetic field. In case a fault developed in the appliance or the circuit, part of the current leaks to the ground. An induced current will arise in the sensing coil, which can drive the relay to open the switches and cut off the mains supply.

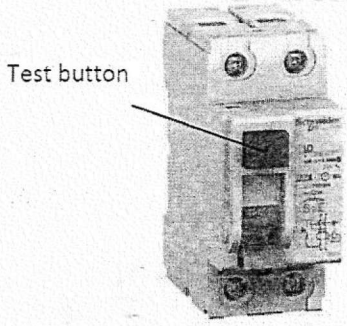


Figure 7.1

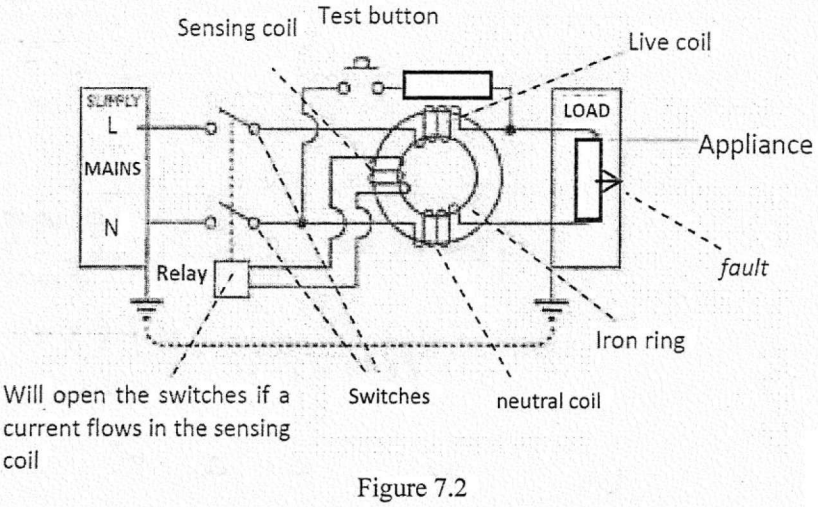


Figure 7.2

(a) Explain why an induced current will appear in the sensing coil when a leakage occurs. (2 marks)

(b) Why does a fuse cannot stop the live current flow when part of the current leaks to the ground? (2 marks)

(c) For a given leakage current, suggest two methods to increase the induced current of the sensing coil. (2 marks)

Exam Number			

(d) Explain why it is preferable to use a laminated iron ring instead of using a solid iron ring of the same dimensions. (2 marks)

(e) It is suggested to test the RCCB circuit monthly by pressing the test button to see if it works normally. Explain how the test button works. (2 marks)

(f) Figure 7.3 shows another design of a RCCB circuit. Explain how this circuit works when there is a fault to cut the current. (4 marks)

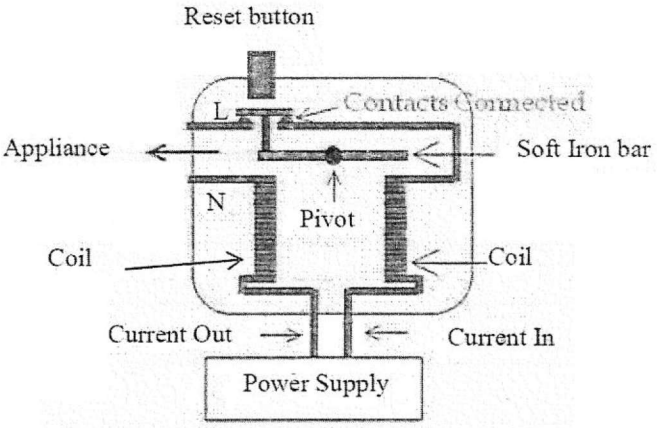


Figure 7.3

***** End of Section C *****