NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER I EXAMINATION 2014-2015

PH1011 - Physics

Nov/Dec 2014 Time Allowed: 2.5 Hours

SEAT NUMBER: | | | | |

MATRICULATION NUMBER: | | | | | | | | | |

INSTRUCTIONS TO CANDIDATES

1. This question and answer booklet contains **EIGHT (8)** questions and comprises of **SEVENTEEN (17)** printed pages.

2. Answer **ALL EIGHT (8)** questions. All workings must be clearly shown.

3. Marks for each question are as indicated.

4. This **IS NOT** an **OPEN BOOK** examination.

5. All your solutions should be written in this booklet within the space provided after each question.

For examiners:

Questions	**1** (15)	**2** (15)	**3** (10)	**4** (10)	**5** (15)	**6** (15)	**7** (10)	**8** (10)	**Total** (100)
Marks									

Q1 (15 marks) /15

(a) As shown in Figure 1(a), a hoop of mass m and radius r is released and it rolls without slipping down the track and over the loop of radius R. Calculate the minimum height h to release the hoop so that the hoop can just make it over the loop. Give your answer for h in terms of R. You may assume that $r \ll R$.

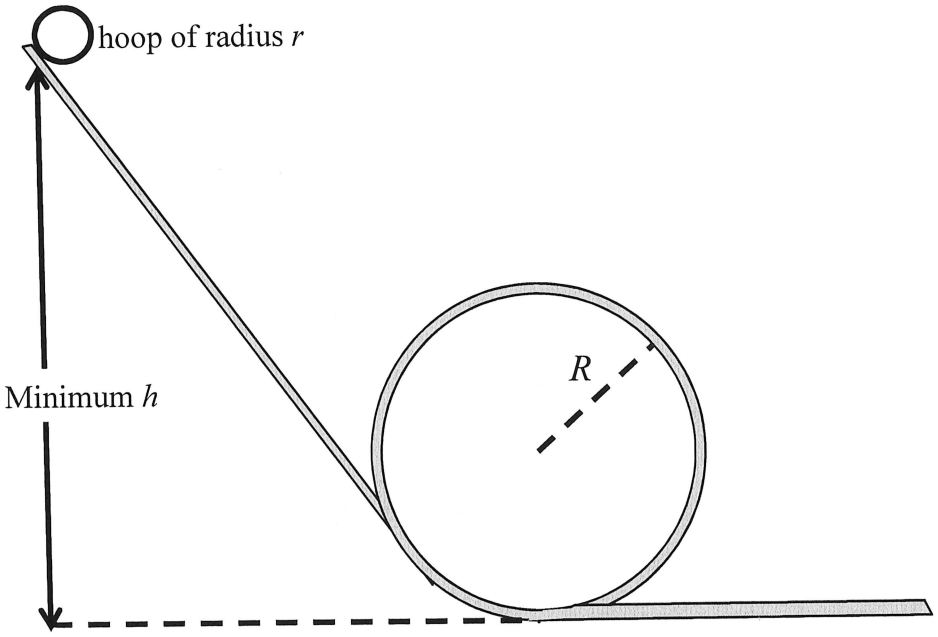

Figure 1(a)

Note: Question 1 continues on page 3

ANS: _____

(b) Sketch how the gravitational potential energy varies with the distance travelled along the track in Figure 1(a).

(c) A ball is launched with $v = 2$ m/s from the bottom of an inclined plane as shown in Figure 1(b). The bottom of the inclined plane is set as the origin of the $xy-$ plane. The angles are $\theta = 40^o$ and $\phi = 15^o$. Calculate the coordinates where the ball hits the incline.

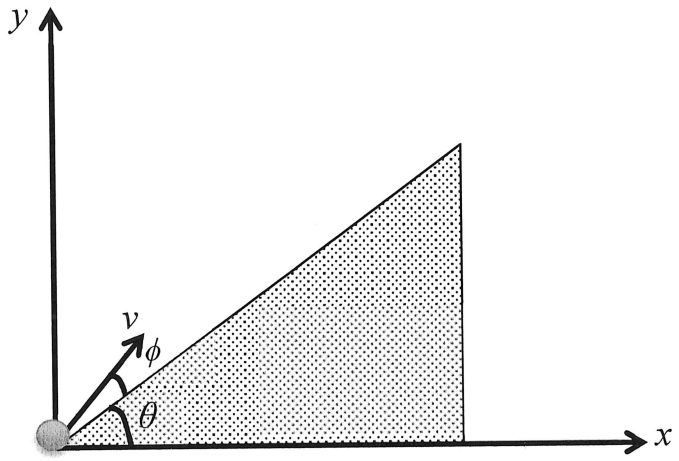

Figure 1(b)

ANS: _____

Q2 (15 marks) /15

(a) A 5 kg rock is shot vertically upwards at 20 m/s. At 10 m above ground, it breaks into two pieces of masses 2 kg and 3 kg. The 3 kg-piece moves horizontally with a velocity of 2 m/s immediately after breaking. Calculate the horizontal distance between the initial point where the 5 kg rock is shot and the landing point of the 2 kg-piece.

Note: Question 2 continues on page 5

ANS: _____

(b) A 1000-kg satellite orbits the Earth at a constant altitude of 2000 km.

(i) What is the period of the satellite?

ANS: _____

(ii) Calculate the total mechanical energy of the satellite in the orbit.

ANS: _____

Q3 (10 marks) /10

As shown in Figure 3, there are 2 masses on each side of the inclined plane. An inextensible string holds the 2 masses over a light pulley. Block A has mass $m_A = 2$ kg and is on the rough side with coefficient of kinetic friction $\mu_k = 0.3$ and block B has mass $m_B = 7$ kg and is on the frictionless smooth side.

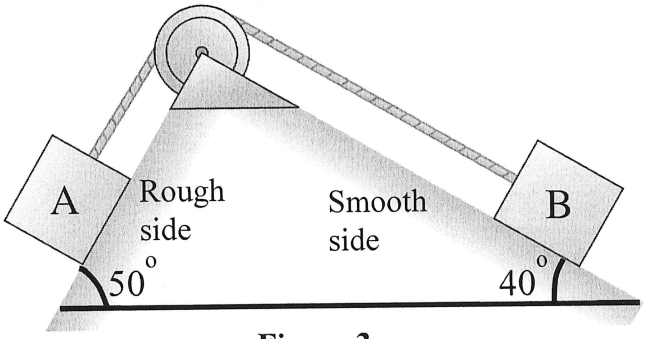

Figure 3

(a) Draw a free body diagram for each block and label all the forces.

Note: Question 3 continues on page 7

(b) Calculate the acceleration of the 2 masses.

ANS: _____

Q4 (10 marks) /10

(a) A non-uniform rod of length l is shown in Figure 4(a). The mass density varies linearly from λ_0 at end A to $1.4\lambda_0$ at end B. You are given that the mass of the rod is $M = 1.2\lambda_0 l$. Show that the centre of mass of the rod is $\frac{19}{36} l$ from end A.

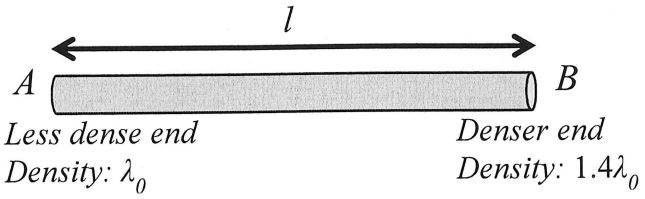

Figure 4(a)

Note: Question 4 continues on page 9

ANS: _____

(b) Now end B of the non-uniform rod is attached to a uniform sphere whose radius is $0.1l$ and the whole structure is released from the vertical position as shown in Figure 4(b). The sphere has the same mass as the rod and the whole structure rotates clockwise as shown. Determine the angular velocity (in terms of l) of the structure when the structure is horizontal. (Hint: the moment of inertia of the rod about its centre of mass (CM) is $0.0724Ml^2$.)

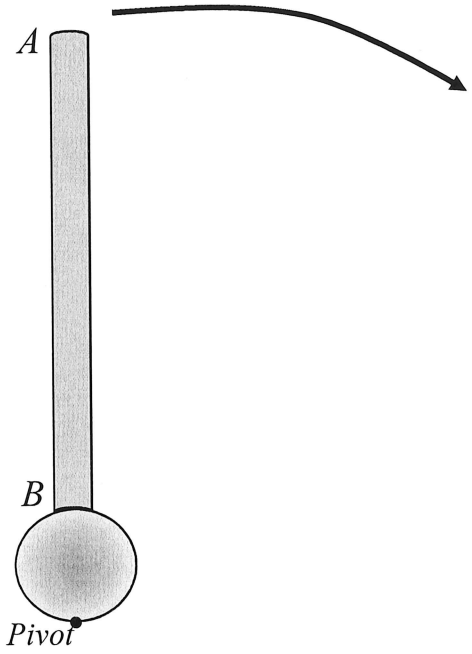

Figure 4(b)

ANS: _____

Q5 (15 marks) /15

2 moles of diatomic ideal gas goes through the processes shown in Figure 5. From A to B, the process is adiabatic; from B to C, it is isothermal at 600 K; from C to D, the process is isochoric; and from D to A, it is isobaric. (Recall that 1 atm = 1.01 x 10^5 Pa.) The gas has a molar mass of 32 g.

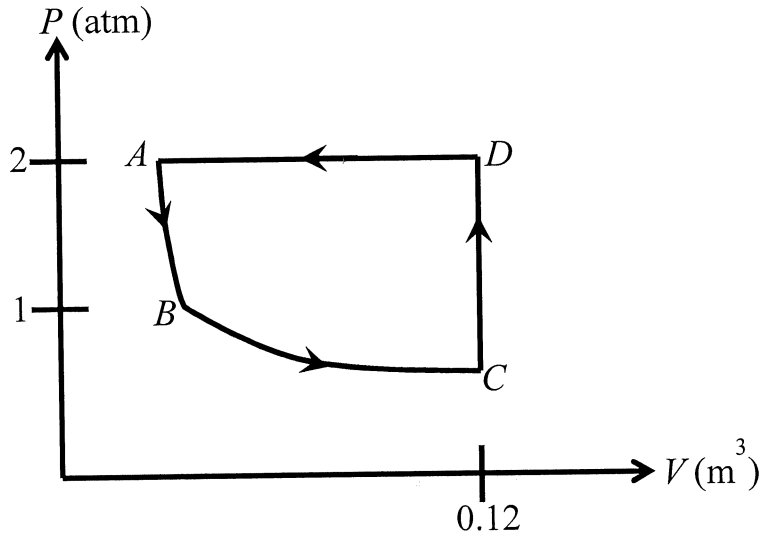

Figure 5

(i) Determine the root-mean-square velocity v_{rms} of the gas during process BC.

ANS: _____

(ii) Determine the temperature of the ideal gas at A. (Hint: Find V_B first.)

ANS: _____

Note: Question 5 continues on page 11

(iii) Fill in the table below with numerical values of ΔU, Q and W (in Joules). The blank area in the rest of the page is meant for your working.

	ΔU	Q	W
Process AB			
Process BC			
Process CD			
Process DA			

Q6 (15 marks) /15

In Figure 6(a), there is a circuit with $V_1 = 5$ V, $V_2 = 10$ V, $V_3 = 1$ V, $R_1 = 1\ \Omega$, $R_2 = 2\ \Omega$ and $R_3 = 3\ \Omega$. Calculate the current passing through resistor R_3.

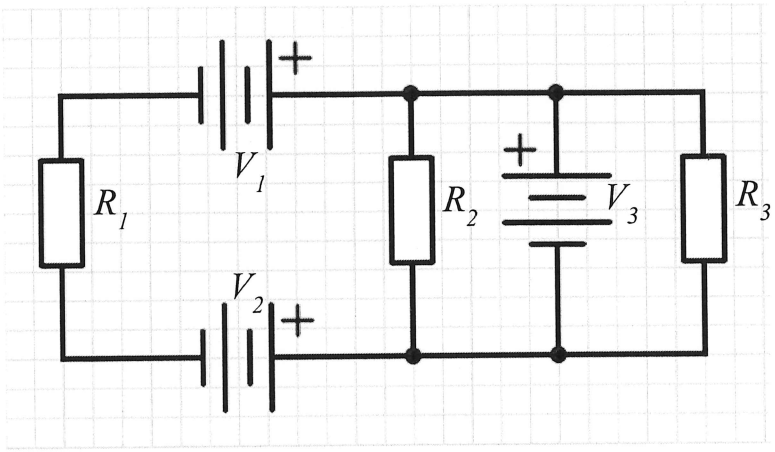

Figure 6(a)

Note: Question 6 continues on page 13

ANS: _____

(b) Consider a RC circuit with $V_1 = 20$ V, $R_1 = 100\,\Omega$ and $R_2 = 200\,\Omega$. The capacitors are $C_1 = 12\,\mu$F and $C_2 = 40\,\mu$F. The switch in the Figure 6(b) has been closed at position a for a long time.

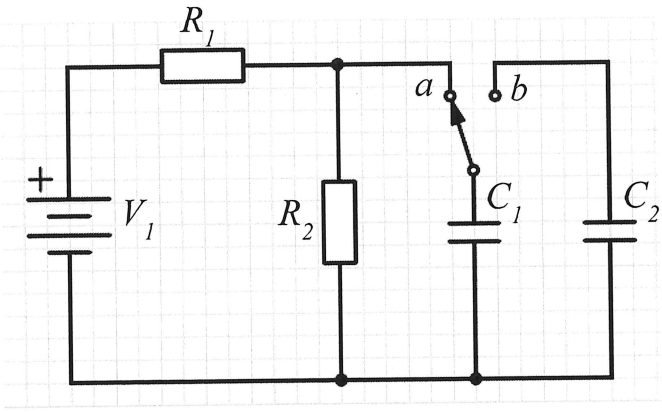

Figure 6(b)

(i) What is the amount of electrical energy stored in the capacitor?

ANS: _____

(ii) The switch is now flipped to position b and remains in position b for a long time. What fraction of the initial charge is in C_1 after a long time?

ANS: _____

Q7 (10 marks) /10

(a) Consider a long wire carrying current I that is parallel to the $x-$ axis. Using Ampere's law, find the magnetic field at the point P as shown in Figure 7(a). This point is at a distance of a from the wire. Give your expression in vector notation.

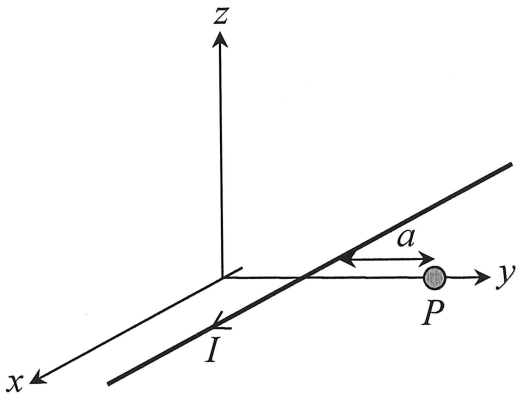

Figure 7(a)

ANS: _____

Note: Question 7 continues on page 15

(b) Now consider a very long thin strip of metal of width w carrying a current I along its length as shown in Figure 7(b). The current is distributed uniformly across the width of the strip. Find the magnetic field at point P which is in the plane of the strip at distance b away from its edge. Give your expression in vector notation. (Hint: It may be useful to use part (a)'s result here by viewing a strip as made up of many long wires.)

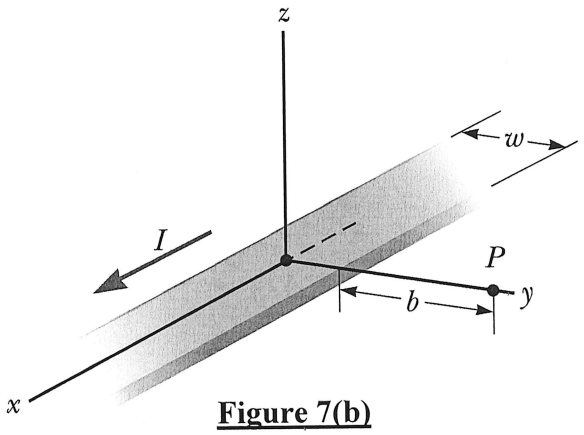

Figure 7(b)

ANS: _____

Q8 (10 marks) /10

A closed rectangular loop of wire of side 10 cm by 2 m, mass 50 g and resistance 120 Ω is dropped from rest at a height of 3 m above a region of uniform magnetic field as shown in Figure 8. Ignore air resistance.

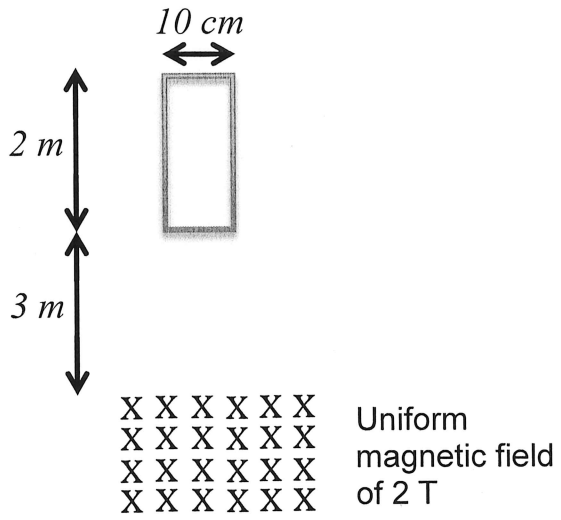

Figure 8

(a) Sketch the velocity-time graph of the loop of wire. Take $t = 0$ to be the time when the loop is released. You need to sketch until the upper width of the wire is well inside the magnetic field.

(b) When only the lower width of the wire is in the magnetic field, there is a possibility that the loop can reach a terminal velocity. Suppose that terminal velocity is reached, what is the value of the terminal velocity?

Note: Question 8 continues on page 17

ANS: _____

(c) Let T be the time interval between the moment when the lower width of the loop just enters the field to the moment when the upper width of the loop just enters the field. Derive an equation that will solve for T. (Note: simplify the equation as much as you can and insert all relevant numbers but do not solve it. The solution is $T = 0.2277$ s and you can use this value to check that your equation is correct.)

ANS: _____

- End of Paper -

PH1011 PHYSICS

Please read the following instructions carefully:

1. **Please do not turn over the question paper until you are told to do so. Disciplinary action may be taken against you if you do so.**

2. You are not allowed to leave the examination hall unless accompanied by an invigilator. You may raise your hand if you need to communicate with the invigilator.

3. Please write your Matriculation Number on the front of the answer book.

4. Please indicate clearly in the answer book (at the appropriate place) if you are continuing the answer to a question elsewhere in the book.