NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER I EXAMINATION 2013-2014

PH1011 - Physics

Nov/Dec 2013 Time Allowed: 2.5 Hours

SEAT NUMBER: | | | | |

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

INSTRUCTIONS TO CANDIDATES

1. This question and answer booklet contains **EIGHT (8)** questions and comprises **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 block is released at height h where h is $R < h < 2.5\ R$. The block slides down the frictionless track and up the vertical circular loop. The block loses contact with the track at position A as shown in Figure 1. Show that $\sin\theta = \frac{2(h-R)}{3R}$.

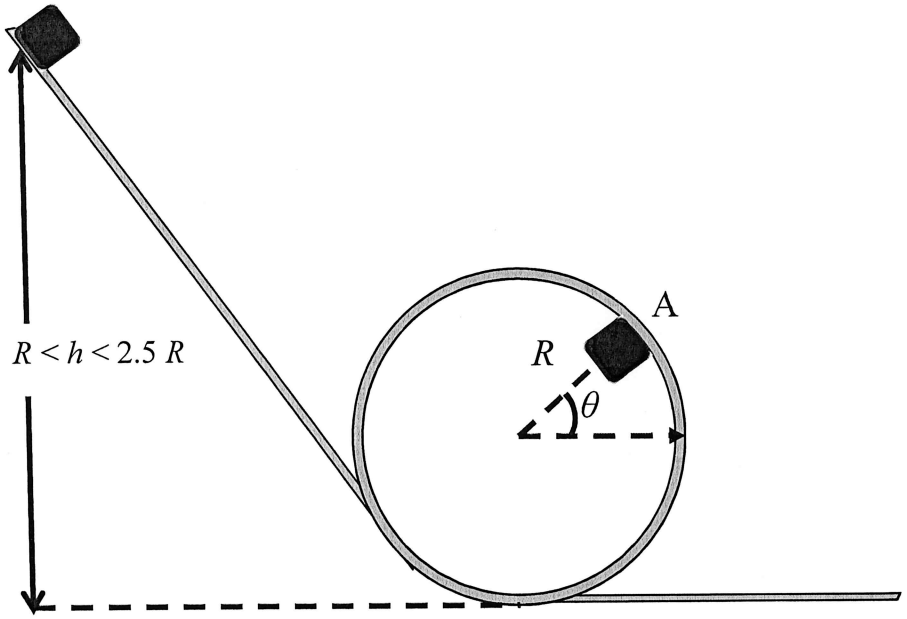


Figure 1(a)

Note: Question No. 1 continues on Page 3

ANS: _____

(b) A truck loaded with watermelons stops suddenly to avoid running over the edge of a washed-out bridge (Figure 1(b)). The quick stop causes one melon to leave the hood of the truck with an initial speed v_i = 12.0 m/s in the horizontal direction. A cross section of the bank has the shape of the bottom half of a parabola, with its vertex at the initial location of the projected watermelon and with the equation $y^2 = 16x$, where x and y are measured in metres. What are the x and y coordinates of the watermelon when it splatters on the bank?

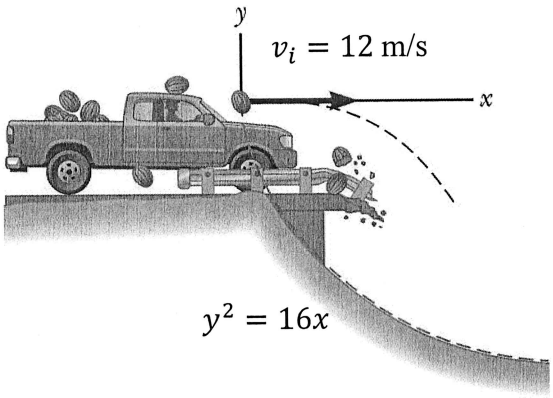


Figure 1(b)

ANS: _____

Q2 (15 marks) /15

(a) As shown in Figure 2, a 10.0 g projectile is travelling east at 2.0 m/s when it suddenly explodes into three pieces. A 3.0 g fragment is shot due west at 10 m/s while another 3.0 g fragment travels 40° north of east at 12 m/s. What are the speed v and angle ϕ of the third fragment just after the explosion?

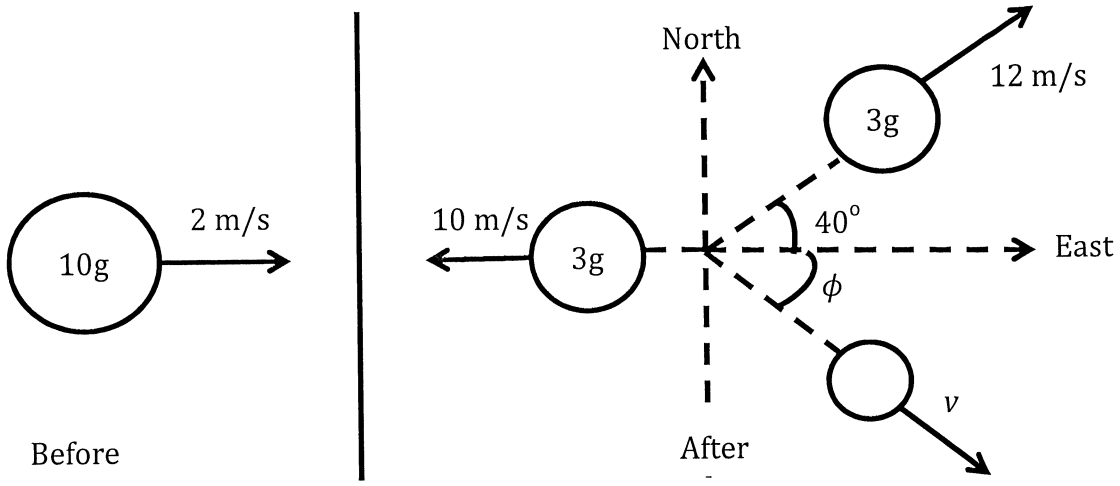


Figure 2

ANS: _____

ANS: _____

Note: Question No. 2 continues on page 5

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

(i) The satellite is moved into a circular orbit with an altitude of 2000 km. What is the change in the system's potential energy?

ANS: _____

(ii) Calculate the total energy that must be added to move the satellite into the circular orbit with an altitude of 2000 km.

ANS: _____

Q3 (10 marks) /10

A friend gives you a uniform, smooth and thin rod of length L and weight W, and challenges you to find an angle θ (the angle the rod makes with the horizontal) such that the rod will rest in equilibrium on the rounded rim of the hemispherical bowl with centre O and radius r.

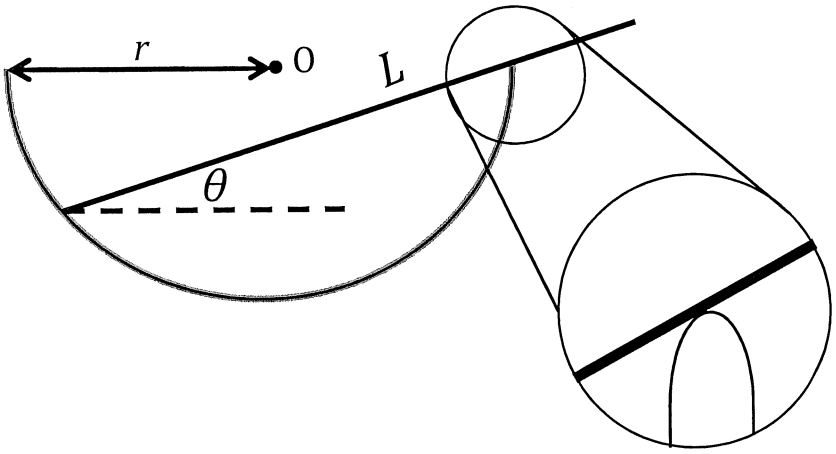
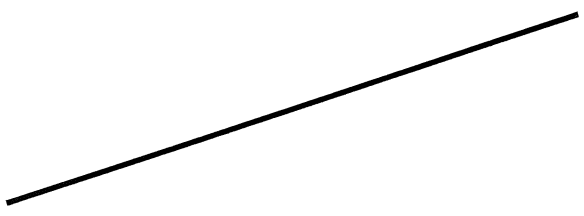


Figure 3

(a) Indicate (with labeled arrows) the 3 forces acting on the rod when it is in equilibrium.



Note: Question No. 3 continues on page 7

(b) By using the conditions for static equilibrium, show that $4r\cos 2\theta = L\cos\theta$.
(Hint: $\cos(A-B) = \cos A\cos B + \sin A\sin B$)

Q4 (10 marks) /10

(a) Calculate the moment of inertia of a uniform thin rod of length l and mass M whose rotational axis is as shown in Figure 4(a).

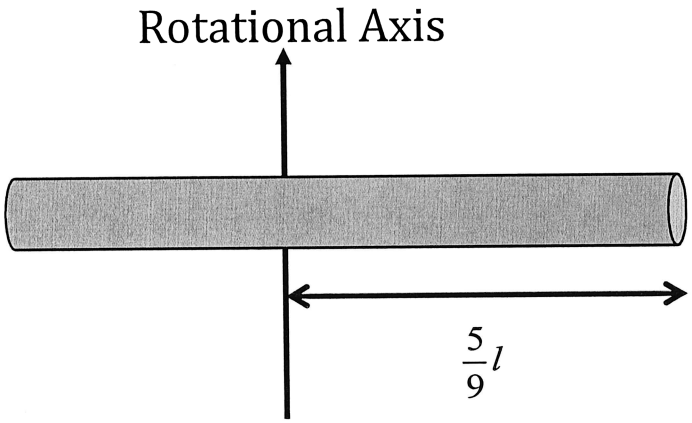


Figure 4(a)

ANS: _____

Note: Question No. 4 continues on page 9

(b) What is the minimum coefficient of static friction μ_s so that a cylinder can roll down an incline of angle θ without slipping? (Hint: You may want to draw a free body diagram of the rolling cylinder and write down the corresponding Newton's 2nd Law equations.)

ANS: _____

Q5 (15 marks) /15

A sample of an ideal gas goes through the process shown in Figure 5. It is not known if the gas is monoatomic or diatomic. From A to B, the process is adiabatic; from B to C, it is isobaric with 329 kJ of heat supplied to the system; from C to D, the process is isothermal; and from D to A, it is isobaric with 354 kJ of heat leaving the system.

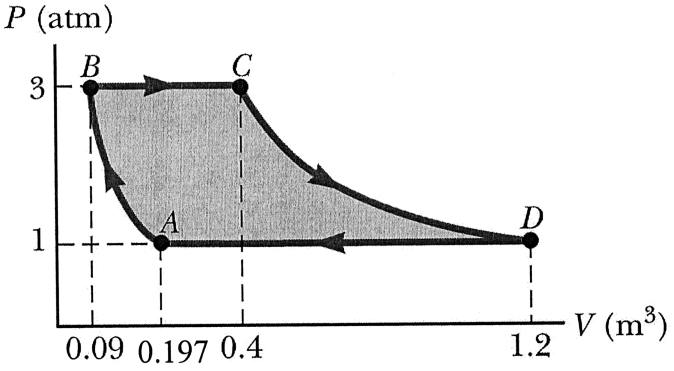


Figure 5

(i) Determine the change in internal energy for process BC.

ANS: _____

(ii) Determine the temperature of the ideal gas for process CD, given that there are 20 moles of the ideal gas.

ANS: _____

Note: Question No. 5 continues on page 11

(iii) Determine v_{rms} of the ideal gas for process CD, assuming that the molar mass of the gas is 32 g/mol.

ANS: _____

(iv) Determine the work done on the gas in process AB where it is given that ΔU_{DA} = -253 kJ.

ANS: _____

(v) Calculate γ for this ideal gas. From the value of γ, deduce whether this ideal gas should be monoatomic or diatomic.

ANS: _____

Q6 (15 marks) /15

Calculate the currents through each resistor of Figure 6(a).

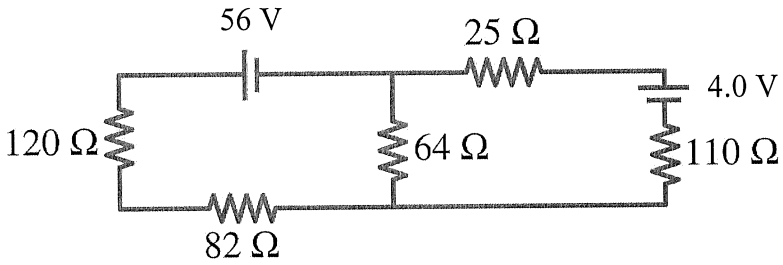


Figure 6(a)

ANS: Through 120 Ω:_____

ANS: Through 82 Ω:_____

ANS: Through 64 Ω:_____

ANS: Through 25 Ω:_____

ANS: Through 110 Ω:_____

Note: Question No. 6 continues on page 13

(b) The switch in the Figure 6(b) has been closed for a very long time.

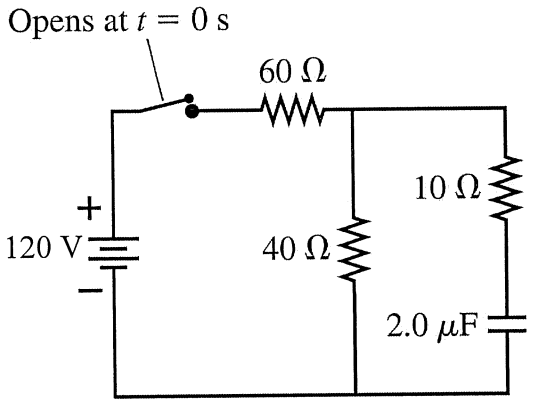


Figure 6(b)

(i) What is the amount of charge on the capacitor?

ANS: _____

(ii) The switch is opened at t = 0 s. At what time will the charge on the capacitor decrease to 10% of its initial value?

ANS: _____

Q7 (10 marks) **/10**

(a) Consider a circular current loop of radius r carrying current I as shown in Figure 7(a). Using Biot-Savart Law, show that the magnetic field at the centre of the current loop is $B = \frac{\mu_0 I}{2r}$.

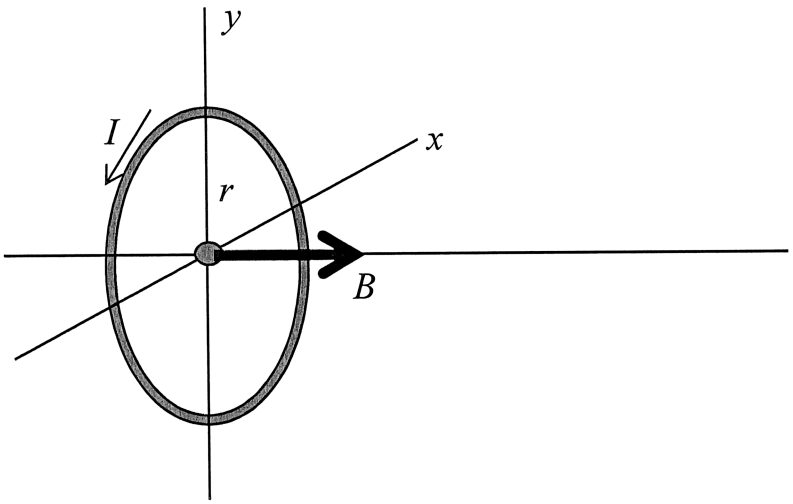


Figure 7(a)

Note: Question No. 7 continues on page 15

ANS: _____

(b) Now consider a flat circular insulating disk of radius R which is uniformly charged with a total charge Q. The disk spins at angular velocity ω about an axis through its centre. What is the magnetic field strength at the centre of the disk? (Hint: The rotating disk can be thought of as the sum of small, concentric current loops.)

ANS: _____

Q8 (10 marks) /10

Consider a perfectly conducting disk of radius r_0 in a constant magnetic field B perpendicular to the plane of the disk. Sliding contacts are provided at the edge of the disk (C_1) and at its axle (C_2) (see Figure 8(a)). This system is Faraday's "homopolar generator." A torque is produced by a mass M hung on a long string wrapped around the perimeter of the disk. The string does not slip on the disk.

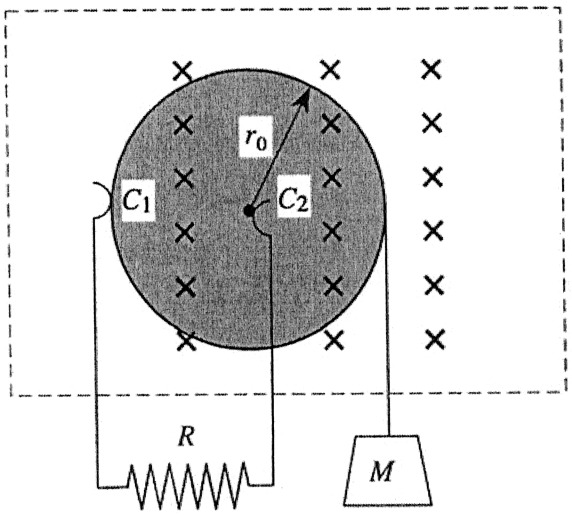


Figure 8(a)

(a) Give an expression for the induced current as a function of the angular velocity ω.

Note: Question No. 8 continues on page 17

ANS: _____

(b) Given a long enough string, this system will reach a constant angular velocity ω_f. Find this ω_f and the associated induced current.

ANS: _____

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.