NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER II EXAMINATION 2013-2014

PH1011 - Physics

April 2014 Time Allowed: 2½ HOURS

SEAT NUMBER: | | | | |

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

INSTRUCTIONS TO CANDIDATES

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

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

3. Marks for each question are as indicated.

4. This is a **CLOSED 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) A 1 kg stone was thrown at a speed of 39.2 m/s at an angle of 30° above the horizontal as shown in Figure 1(a). All frictional forces were negligible.

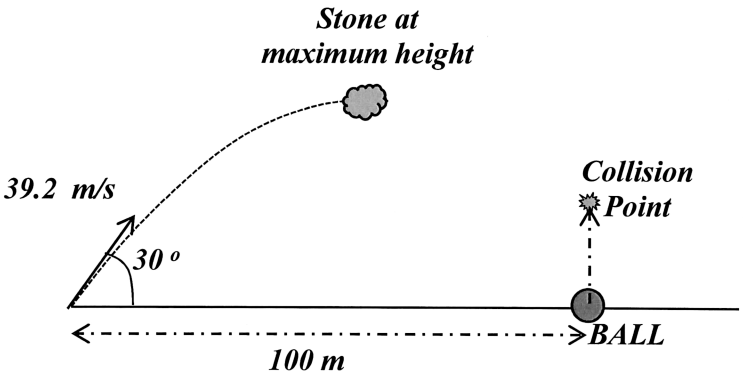


Figure 1(a)

(i) Prove that the stone took two seconds to reach the maximum height.

(ii) Calculate the kinetic energy of the stone at the position of maximum height.

ANS: _____

Note: Question 1 continues on Page 3

(iii) When the stone was at its maximum height, a ball was thrown vertically up at 100 m away from the launch point of the stone (Figure 1(a)). The two objects collided after the ball has travelled for 1 second.

(1) How high was the stone from the ground when the collision occurred?

ANS: _____

(2) What is the launch speed of the ball?

ANS: _____

Note: Question 1 continues on Page 4

(b) Two identical rubber bunds *A* and *B*, connected to a light inextensible string were made to swing around a finger on a horizontal plane (Figure 1(b)). The mass of each bund is 0.10 kg. Figure 1(b) shows the values of the separation of the finger and each bund.

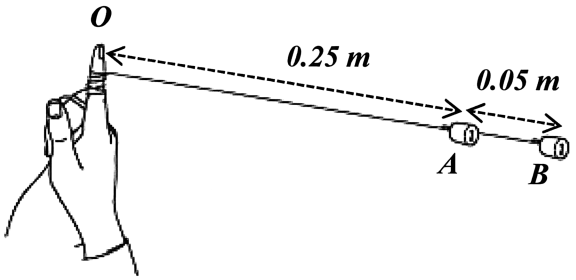


Figure 1(b)

(i) Assuming the string is horizontal and the angular speed of the two bunds is 10 rad/s. What is the tension of the part of the string separating

(1) the two bunds?

(2) bund *A* and the finger?

ANS: _____

ANS: _____

(ii) By considering all the forces acting on each bund, explain, why in reality the two tensions calculated above can never act along the horizontal direction.

ANS: _____

_____

(iii) The two bunds continue to revolve around the finger at approximately the same angular speed. If the string were to break, which segment, ***OA*** or ***AB*** will break first?

ANS: _____

_____

Q2 (15 marks) /15

(a) A gun fires a bullet vertically into a 1.60 kg block of wood at rest on a thin horizontal sheet as shown in Figure 2(a). If the bullet has a mass of 20.0 g and a speed of 310 m/s, how high will the block rise into the air after the bullet becomes embedded in it?

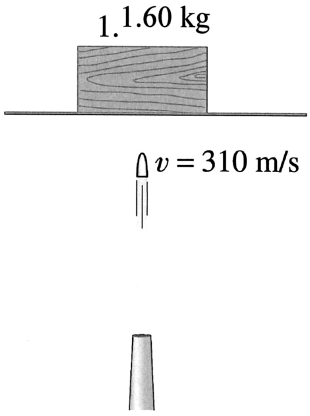


Figure 2(a)

ANS: _____

Note: Question 2 continues on page 6

(b) Consider the assembly of three masses in Figure 2(b).

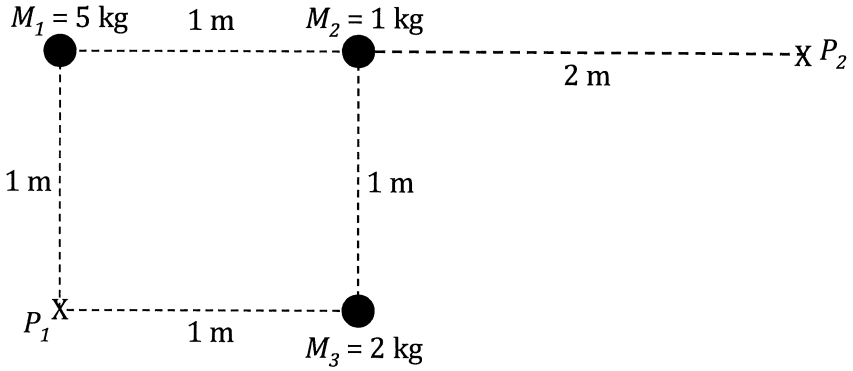


Figure 2(b)

(i) Calculate the gravitational potential, V, at points P_1 and P_2.

ANS: _____

ANS: _____

(ii) Calculate the gravitational potential energy stored in this assembly. (Hint: calculate the work done required to assemble the system.)

ANS: _____

Q3 (10 marks) /10

Consider 2 blocks, A and B, held by an inextensible string over a light pulley as shown in Figure 3(a). Block A has a mass of 10 kg and block B has a mass of 3 kg. The angle of the slope is $\theta = 40^0$. There is no friction between block A and the slope but the coefficient of kinetic friction between blocks A and B is $\mu_k = 0.4$.

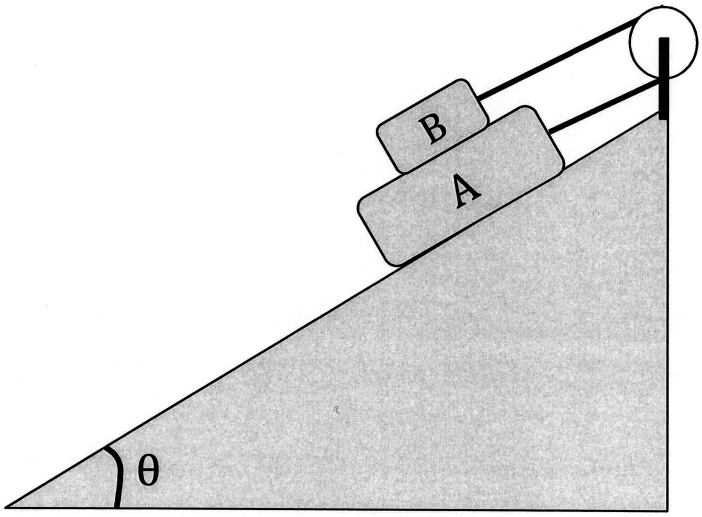


Figure 3(a)

(a) Indicate (with labeled arrows) all the forces acting on blocks A and B

(b) Briefly explain how the free body diagrams will change if the pulley has mass and the string moves without slipping on the pulley.

ANS: _____

_____

Note: Question 3 continues on page 8

(c) Calculate the acceleration of Block A.

ANS: _____

Q4 (10 marks) /10

(a) Calculate the moment of inertia of a system of two uniform thin rods each of length l and mass M about rotational axis A where Figure 4(a) shows the top view.

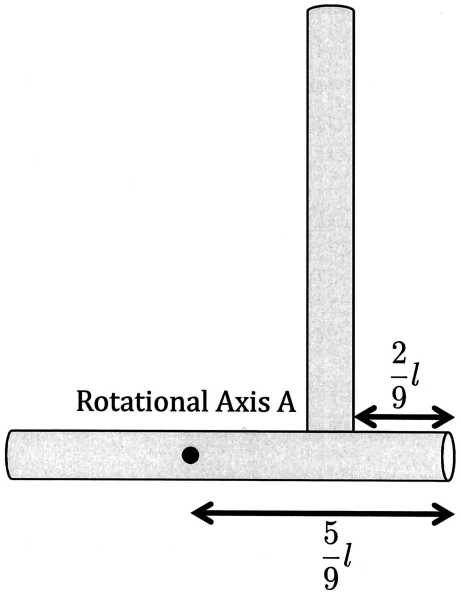


Figure 4(a)

ANS: _____

Note: Question 4 continues on page 10

(b) A 250 kg beam 2.8 m in length slides broadside down the ice with a speed of 20 m/s (Figure 4(b)). A 70 kg man at rest grabs one end as it goes past and hangs on as both he and the beam go spinning down the ice. Assume frictionless motion.

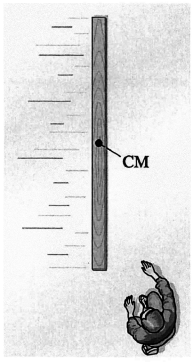


Figure 4(b)

(i) How fast does the centre of mass of the system move after the collision?

ANS: _____

(ii) With what angular velocity does the system rotate about the centre of mass of the system?

ANS: _____

Q5 (15 marks) /15

One mole of diatomic ideal gas is used as the working substance for an engine. Each cycle of this engine is made up of two adiabatic processes and two isobaric processes as shown in Figure 5. The volume V, pressure P and temperature T for points A, B, C, D were shown. The molar heat capacity at constant pressure for the ideal gas is C_p.

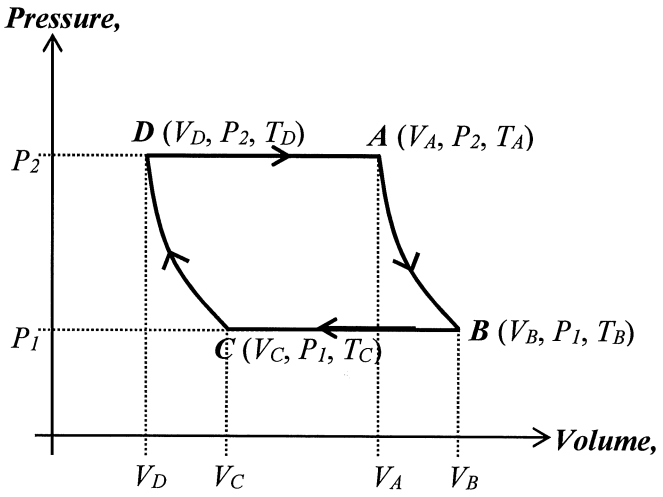


Figure 5

(i) Identify the two adiabatic processes. ANS: _____

(ii) Rank these four temperatures: T_A, T_B, T_C, T_D from the lowest to highest.

ANS: _____

(iii) Hence rank the corresponding internal energies: U_A, U_B, U_C, U_D from the lowest to highest.

ANS: _____

(iv) An adiabatic curve has the equation of the form $PV^{\gamma} = k$ where γ and k are constants. Prove that the work done by the gas for an adiabatic process is $\frac{1}{1-\gamma}(P_f V_f - P_i V_i)$.

ANS: _____

Note: Question 5 continues on page 12

(v) Write down expressions for the work done by the gas in the engine for the 4 processes in terms of γ as well as the respective V, P and T given in Figure 5.
Summarize your end results in the table given. Indicate the +/– signs clearly.

Process	**A → B**	**B → C**	**C → D**	**D → A**
Work done by engine				
Sign				

(vi) In terms of C_p as well as the respective V, P and T given in the diagram, write down expressions for the heat energy exchange between the engine and the environment for processes: B → C and D → A. Summarize your end results in the table given. Indicate, by circling the relevant word, whether it is heat energy entering or leaving the engine.

Process	***B → C***	***D → A***
Heat energy exchange		
	(Enters / leaves) engine	**(Enters / leaves) engine**

(vii) Hence derive an expression for the efficiency of this engine in terms of T_A, T_B, T_C and T_D. The definition of efficiency is $\eta = \frac{\text{net Work}}{\text{total heat entered}}$.

ANS: _____

Q6 (15 marks)

/15

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

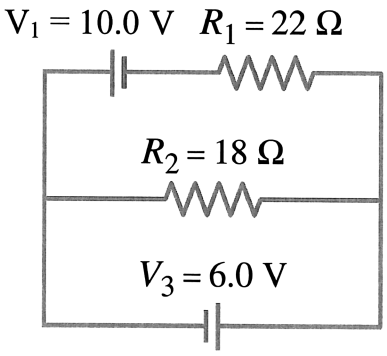


Figure 6(a)

ANS: In 22 Ω:_____

ANS: In 18 Ω:_____

Note: Question 6 continues on page 14

(b) The capacitor in Figure 6(b) was initially uncharged and at $t = 0$ s, the switch is closed at position *a*.

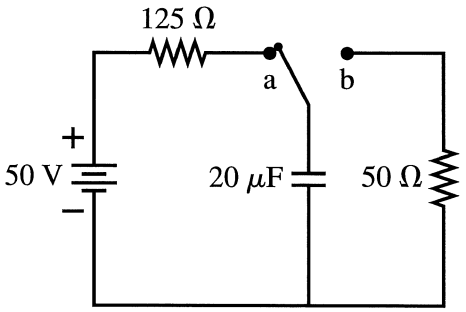


Figure 6(b)

(i) What is the initial current through the 125 Ω resistor?

ANS: _____

(ii) What is the charge in the capacitor after a long time?

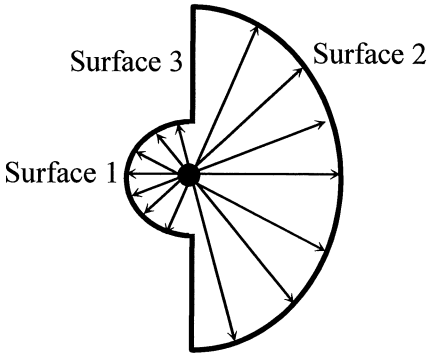
ANS: _____

(iii) The switch is now flipped to position *b*. The fully charged capacitor now discharges through the 50 Ω resistor. How long does the capacitor take to discharge 30% of its stored energy?

ANS: _____

Q7 (10 marks) **/10**

(a) Consider a charge q at the centre of two hemispheres of different radii (Figure 7(a)). Hemisphere 1 is called surface 1 and has a radius 5 cm. Hemisphere 2 is called surface 2 and has a radius of 15 cm.



Side View

Figure 7(a)

(i) State the net electric flux through surface 3.

ANS: _____

(ii) Calculate the net electric flux through surface 1.

ANS: _____

(iii) Calculate the net electric flux through surface 2.

ANS: _____

(iv) Show that Gauss law: $\oint \vec{E} \cdot d\vec{A} = \frac{Q_{enc}}{\epsilon_0}$ holds for this closed surface.

_____

_____

Note: Question 7 continues on page 16

(b) Consider two current carrying wires of length 1 m each and are held in equilibrium by a spring which has an unextended length of 0.75 m and a spring constant of 0.005 N/m. Figure 7(b) shows the cross-sectional view where each wire carries a current of 20 A in opposite directions. Figure 7(c) shows the top view. Calculate the extension of the spring. Assume that there is no friction between the wires and the floor and the wires are rigid.

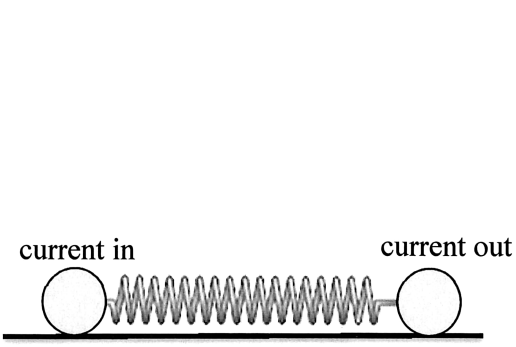


Figure 7(b)

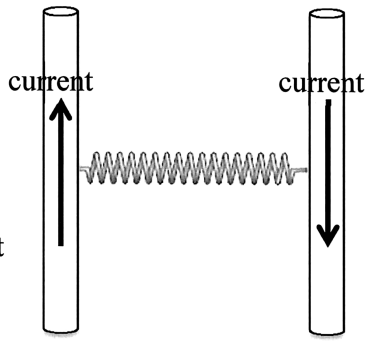


Figure 7(c)

ANS: _____

Q8 (10 marks) /10

The square loop shown in Figure 8(a) moves into a 0.80 T magnetic field at a constant speed of 10 m/s. The loop has a resistance of 0.10 Ω, and it enters the field at $t = 0$ s.

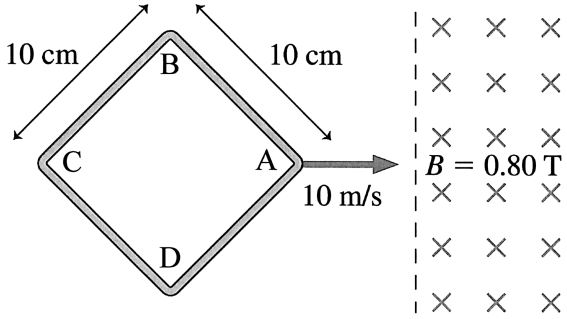


Figure 8(a)

(a) Find the induced current in the loop as a function of time.

(b) What is the maximum current? ANS: _____

(c) What is the position of the loop when the current is maximum?

_____

(d) Sketch a graph of I versus t from $t = 0$ s to $t = 0.020$ s.

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.