NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER II EXAMINATION 2012–2013

PH1011 – Physics

April/May 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 **EIGHTEEN (18)** 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									

/15

1.

Take acceleration of free fall as $g = 9.81$ m/s^2. You can ignore air resistance for this question.

a. An object is projected downward at an angle of 30° below the horizontal from the top of a building 170 m high (Figure 1a). Its initial speed is 45 m/s.

i. Determine the time taken by the object to strike the ground.

ii. How far from the base of the building will the object land?

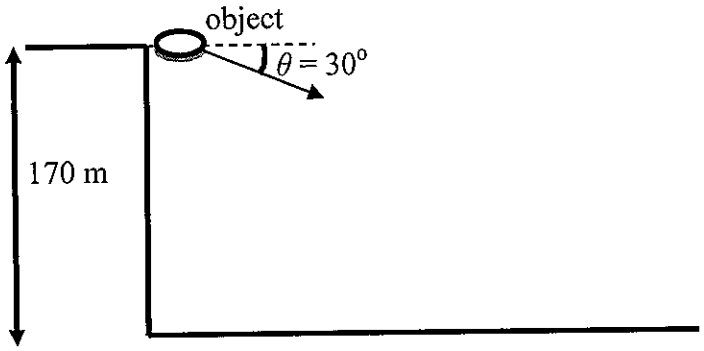


Figure 1a

ANS: _____

ANS: _____

Note: Question No. 1 continues on Page 3

iii. Now consider a different situation: a carriage starts from rest at ground level with acceleration $a(t) = 2t^2 + 6t$ at $t = 0$ s. The carriage is moving to the right (see Figure 1b). The object is projected horizontally at $v = 20$ m/s at $t = 3$ s from the top of the building. Determine the distance between the object and the carriage when the target strikes the ground.

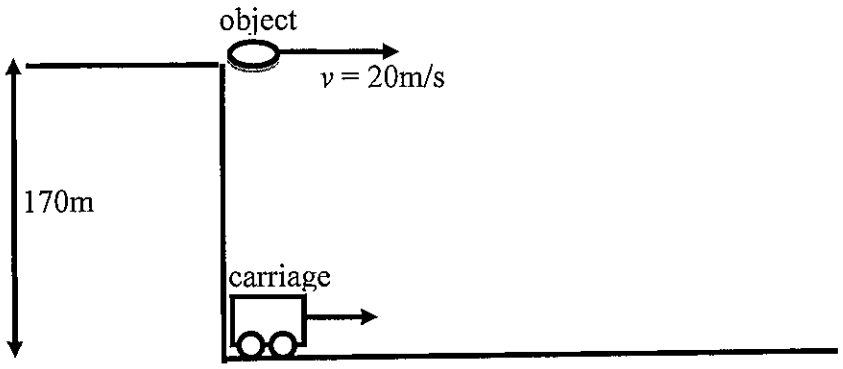


Figure 1b

ANS: _____

(10 marks)

Note: Question No. 1 continues on Page 4

b. An amusement park ride consists of a large vertical cylinder that spins about its axis fast enough that any person inside is held up against the wall when the floor drops away (See Figure 1c). The coefficient of static friction between person and wall is μ_s, and the radius of the cylinder is R.

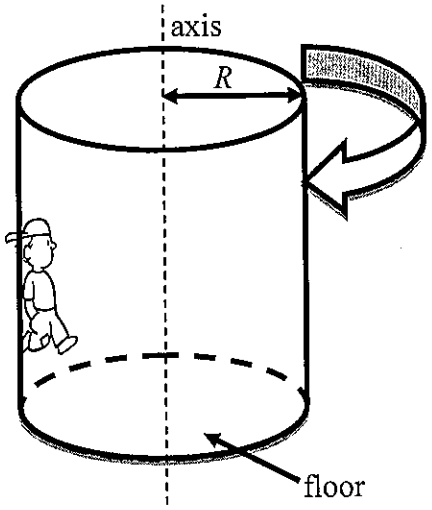


Figure 1c

i. Use the sketch provided below, draw and label arrows to indicate the forces acting on the boy.

ii. Show that the maximum period of revolution necessary to keep the person from falling is $T = (4\pi^2 R\mu_s/g)^{1/2}$.

(5 marks)

/15

2.

a. One end of a uniform metre stick is placed against a vertical wall. The other end is held by a lightweight cord that makes an angle of 15° with the stick (Figure 2a). The coefficient of static friction between the end of the metre stick and the wall is 0.40. (You can assume that the static friction is pointing upwards.) A block which has the same weight as the metre stick is suspended from the stick at a distance x from the wall.

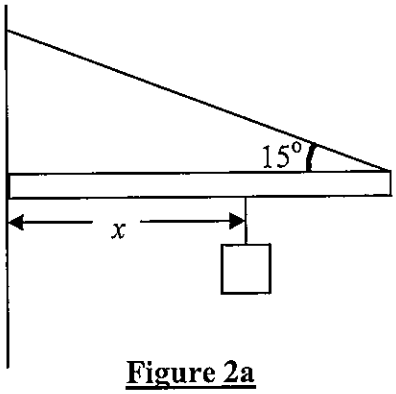
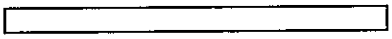


Figure 2a

i. Using the sketch provided below, draw and label arrows to indicate the forces acting on the metre stick.



Note: Question No. 2 continues on Page 6

ii. Determine the minimum value of x for which the stick can remain in equilibrium.

ANS: _____

(9 marks)

Note: Question No. 2 continues on Page 7

b. A 30.0 kg child stands at one end of a 70.0 kg boat that is 4.00 m in length (Figure 2b). The boat is initially 3.00 m from the pier. The child notices a turtle on a rock near the far end of the boat and proceeds to walk to that end to catch the turtle. You can neglect friction between the boat and the water.

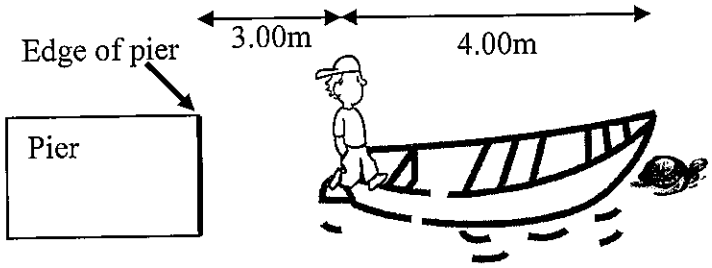


Figure 2b

i. Describe the subsequent motion of the system (child and boat).

Note: Question No. 2 continues on Page 8

ii. Determine the distance between the child and the edge of the pier when he reaches the far end of the boat.

ANS: _____

iii. Will he be able to reach the turtle? (Assume he can reach out 1.00m from the end of the boat.)

_____

(6 marks)

/10

3. A small wooden block with mass 0.900 kg is suspended from the lower end of a light cord that is 1.60 m long. The block is initially at rest. A bullet with mass 12.0 g is fired at the block with a horizontal velocity v_0. The bullet strikes the block and becomes embedded in it. After the collision, the combined object swings on the end of the cord. When the block has risen a vertical height of 0.800 m, which is not the highest point, the tension in the cord is 4.80 N. What was the initial speed v_0 of the bullet?

ANS: _____

(10 marks)

/10

4. A string is wound around a uniform disk of radius R and mass M. The disk is released

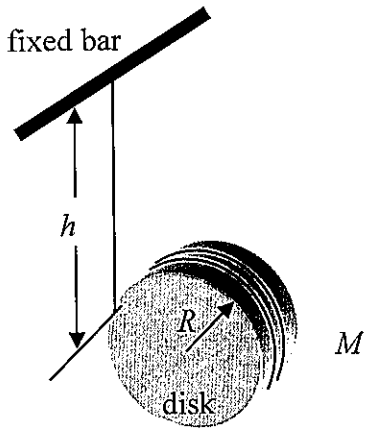


Figure 4

from rest when the string is vertical and its top end is tied to a fixed bar (Figure 4).

a. Show that the tension in the string is one-third the weight of the disk.

ANS: _____

Note: Question No. 4 continues on Page 11

b. Show that the magnitude of the acceleration of the centre of mass is $2g/3$.

ANS:_____

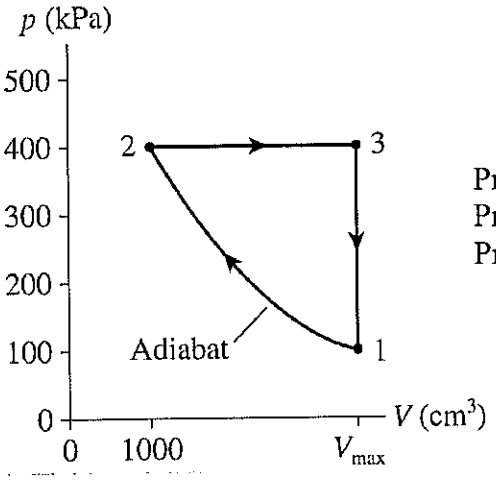
c. Show that the speed of the centre of mass is $(4gh/3)^{1/2}$ when the disk has descended to height h below the fixed bar.

ANS:_____

(10 marks)

/15

5. The heat engine shown in Figure 5 uses 0.020 mol of a monatomic gas as the working substance. Note that $c_v = 1.5R$, $c_p = 2.5R$ and $\gamma = 5/3$.



Process 1 → 2: Adiabatic compression
Process 2 → 3: Isobaric expansion
Process 3 → 1: Isochoric cooling

Figure 5

a. Assuming that the gas behaves ideally and you are given that T_3 = 5528 K, determine the temperatures, T_1, T_2 and volume V_{max}.

ANS: _____

ANS: _____

ANS: _____

Note: Question No. 5 continues on Page 13

b. Fill in the table with numerical values for the internal energy, ΔU, the work done by gas, W and the heat supplied, Q for each of the three processes.

	ΔU	W	Q
1 → 2			
2 → 3			
3 → 1			

c. Calculate the engine's thermal efficiency η i.e. the ratio of the total work done to the heat supplied for each cycle 1 → 2 → 3 → 1.

ANS: _____

(15 marks)

/15

6.

The switch in Figure 6 has been in position *a* for a long time. At $t = 0$ s, it is suddenly switched to position *b* for 1.0s, then back to *a*.

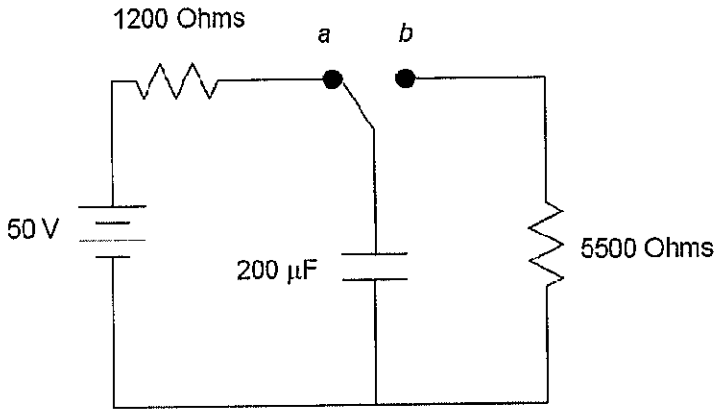


Figure 6

a. What is the capacitor voltage at t = 0 s?

ANS: _____

b. What is the energy stored in the capacitor at t = 0 s?

ANS: _____

Note: Question No. 6 continues on Page 15

c. How much has the capacitor voltage decreased to at $t = 1$ s?

ANS:_____

d. What is the energy stored in the capacitor at $t = 1$ s?

ANS:_____

e. How much energy is dissipated by the 5500 Ohm resistor?

ANS:_____

(15 marks)

/10

7.

A power line carries a current of 95A west along the tops of 8.5-m-high poles.

a. What is the magnitude and direction of the magnetic field produced by this wire at the ground directly below?

ANS: _____

b. The Earth's magnetic field is 5 x 10^{-5} T in the north-south direction. How far from the power line is the net magnetic field zero?

ANS: _____

(10 marks)

/10

8. Note: The permeability of free space is μ_o.

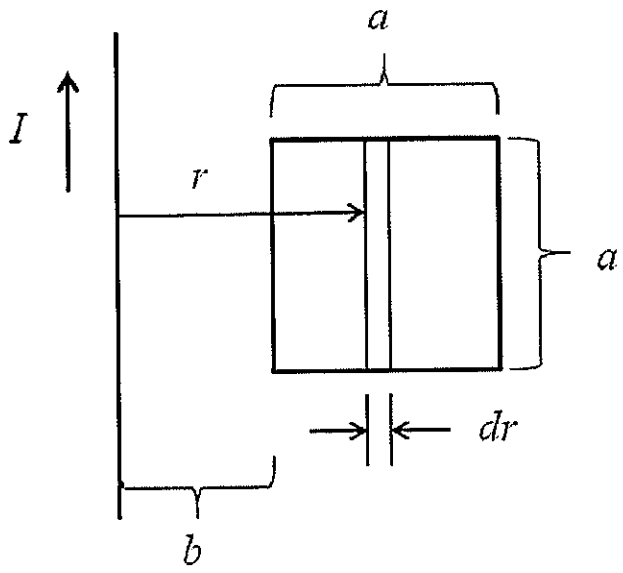


Figure 8

a. Determine the magnetic flux through a square conducting loop of side a (Figure 8) if one side is parallel to and a distance b from a straight wire that carries a current I.

ANS: _____

Note: Question No. 8 continues on Page 18

b. Referring to Figure 8, now the loop is pulled away from the wire at a constant speed v and $b = vt$ at any time t.

i. What is the emf induced in the loop at time t?

ANS: _____

ii. Does the induced current flow clockwise or counterclockwise in the loop?

ANS: _____

iii. The resistance of the loop is R. Determine the force F at time t required to pull the loop away in terms of any of the relevant variables, I, a, b, v, t and R.

ANS: _____

(10 marks)

- 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.