End-Semester Test (AY20/21 S2)

EP0605 – Advanced Physics **Time Allowed: 1½ hour**

Instructions to Candidates **Max Marks**: 100

1. All the Singapore Polytechnic examination rules must be strictly adhered to.
2. This paper consists of **6** questions.
3. Answer all the questions in this question booklet. All working must be shown.
4. This paper consists of **8** pages (inclusive of the cover page).
5. Fill in your personal particulars below.

Name :			
Admission No :		S/No	
Class :		Date :	

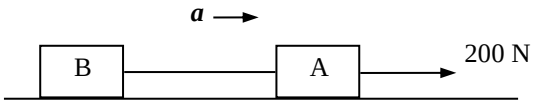
Question	**Marks**
1	
2	
3	
4	
5	
6	
Total	

1. An object of mass 0.0200 kg is moving in a plane. The x and y coordinates (measured in metres) of the object are given by $x(t) = t^3 - t^2$ and $y(t) = 4t^3 + t$ where all quantities are in SI units.

   a) Find the x- and y- components of the object's velocity.
   b) At $t = 2.00$ s, find the x- and y- components of the object's acceleration.
   c) At $t = 2.00$ s, find the magnitude and direction of the net force acting on the object.
   d) What is the total work done on the object between $t = 0$ and $t = 2.00$ s?

(17 marks)

2. The below diagram shows two objects A and B connected by a string. Object A is towed by a 200 N horizontal force to the right. The mass of A is 20 kg while that of B is 10 kg. The coefficient of kinetic friction for both objects is 0.50. The initial velocity of both objects is zero.



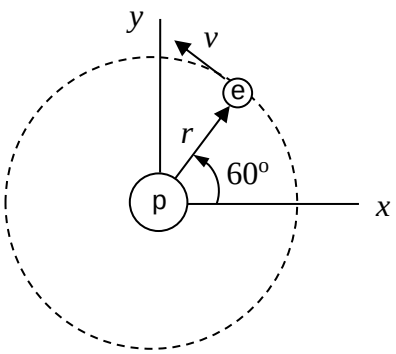
a) Draw the free body diagrams of A and B.
b) Determine the tension in the string between A and B and acceleration of the two objects.
c) Determine the velocity of A and B when t = 5.0 s.

(17 marks)

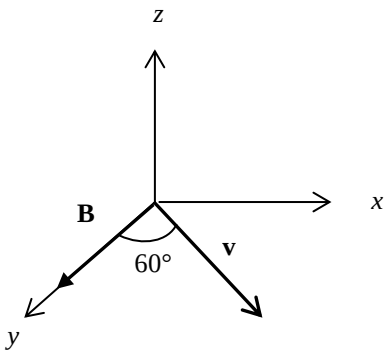
3. The electron and proton in a hydrogen atom are separated by an average distance of 5.3×10^{-11} m. Assume the electron orbits with uniform circular motion.

   a) What is the magnitude of the electric force on the electron?
   b) What is the electron's speed?
   c) If the electron's obit is on the *x*-*y* plane, express the electron's instantaneous velocity at the position shown in the below figure in terms of unit vectors **i** and **j**.

(17 marks)



4. A proton moves at 2.0×10^5 m/s through a uniform magnetic field with a magnitude 1.5 T. The magnetic field is directed along the positive *y*-axis as shown in the below figure. The velocity of the proton is in the *x*-*y* plane at an angle of 60^o to the positive *y*-axis.

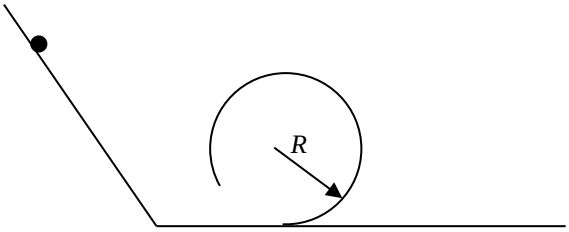


a) Express the velocity and the magnetic field in terms of unit vectors.

b) Find the force on the proton.

(17 marks)

5. In the below figure, an object starts from rest at a certain height on an inclined plane. Once it reaches the bottom of the inclined plane, it moves in a straight line when it encounters a circular loop of radius *R*. There is no friction anywhere in the journey. The mass of the object is *m* and the acceleration due to gravity is *g*. Ignore rolling for the object. Express your answers in *m*, *R* and *g*.



a) Draw the free body diagram for the object at the bottom of the circular loop as well as the top of the circular loop.
b) What is the minimum speed that the object can have at the top of the loop if it is to complete the loop without leaving the track?
c) Hence, calculate the minimum speed of the object at the bottom of the loop with which it can successfully make it around the circular loop.
d) What is the minimum height at which the object must start on the inclined plane to successfully make it around the circular loop?

(17 marks)

6. A point charge $q = -9.00$ nC is located at the origin. The electric field due to this charge is $\mathbf{E} = (7.80\,\mathbf{i} + 10.4\,\mathbf{j})$ N/C at a certain point X. [1nC = 10^{-9} C].

   a) Find the coordinates of point X.
   b) Find the electric potential at point X.

(15 marks)

Formula sheet

Kinematics

$v_x = v_{0x} + a_x t$

$v_x^{\,2} = v_{0x}^{\,2} + 2a_x(x - x_0)$

$x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$

$\vec{v} = \frac{d\vec{r}}{dt}, \quad \vec{a} = \frac{d\vec{v}}{dt}$

$y = (tan\theta)x - (\frac{g}{2v^2 cos^2\theta})x^2$

$R = \frac{v^2 sin 2\theta}{g}$

Dynamics

$\vec{F} = m\frac{d\vec{v}}{dt} = m\vec{a}, F = \mu N$

$a = \frac{dv}{dt}, a = \frac{v^2}{r}, F = m\frac{v^2}{r}$

$W = \int \vec{F}.\vec{dr}, W_{net} = K_f - K_i$

$KE = \frac{1}{2}mv^2, \ PE = mgh$

$P = \frac{W}{t}, \ P = \frac{dW}{dt}$

Static electricity

$F = k\frac{q_1 q_2}{r^2}, k = \frac{1}{4\pi\varepsilon_o}$

$F = qE$

$V = k\frac{q}{r}, U = qV$

$\Phi_E = \oint \vec{E}.d\vec{A} = \frac{q}{\varepsilon_o}$

$V = Ed, W = qV, E = \frac{kq}{r^2}$

$Q = It \quad V = IR$

$P = VI = I^2R = \frac{V^2}{R}$

Magnetism

$\vec{F} = q\vec{v} \times \vec{B} \quad \vec{F} = i\vec{L} \times \vec{B}$

$e.m.f. = -N\frac{d\Phi_B}{dt}$

$\Phi_B = \vec{B} \bullet \vec{A}$

Constants

g = 9.80 m/s^2

Charge on electron

$q = -1.60 \times 10^{-19}$ C

Charge on proton

$q = 1.60 \times 10^{-19}$ C

Coulomb's constant

$k = 9 \times 10^9$ N m^2 C^{-2}

Mass of proton

$m_p = 1.67 \times 10^{-27}$ kg

Mass of electron

$m_e = 9.11 \times 10^{-31}$ kg

Permittivity of free space

$\varepsilon_o = 8.85 \times 10^{-12}$ C^2 N^{-1} m^{-2}

Speed of light in vacuum

$c = 3.00 \times 10^8$ m s^{-1}