SINGAPORE POLYTECHNIC

2016/17 SEMESTER TWO EXAMINATION

DASE/DEEE/DCPE/DESM/DES/DEB/DME/DBEN/DARE/DMRO
DIT/DBIT/DISM/DDA/DVEMG

3rd Year Full-Time

PHYSICS Time allowed: 2 hours

Instructions to Candidates:

1. The examination rules set out on the last page of the answer booklet are to be complied with.

2. This paper consists of **TWO sections** printed on 5 pages (inclusive of cover page and formula sheet).

   Section A: 5 questions, 14 marks each. The total mark of the questions in this section is 70 marks. You may answer as many questions as you wish. The marks from all questions you answered will be added, but the maximum mark you may obtain from this section is **50 marks**.

   Section B: 3 questions, total mark is 50.
   Answer all three questions in this section.

3. Please write your name, admission number and seat number on the formula sheet.

4. All answers are to be written in the answer booklet provided.

5. All answers must be given to the appropriate number of significant figures.

6. Take acceleration due to gravity, $g = 9.80\ \text{m/s}^2$.

7. Except for sketches, graphs and diagrams, no solution is to be written in pencil. Failure to comply will result in loss of marks.

<u>Section A</u> (50 marks)

The total mark of the questions in this section is 70 marks. You may answer as many questions as you wish. The marks from all questions you answered will be added, but the maximum mark you may obtain from this section is 50 marks.

A1. A wave on a string, described by $y(x, t) = A\sin(kx - \omega t)$, moves at 10 cm/s. The symbols in the wave function have their usual meaning. The wavelength of the wave is 50 cm while the maximum displacement of any particle on the string is 10 cm.

a) Find A, k and ω and hence write the wave function.
b) Derive the expression for the velocity of any particle on the string.
c) What is the velocity of a particle when its displacement is 5 cm?

(14 marks)

A2. An object of mass m has linear momentum given by $\mathbf{p}(t) = C[\cos(kt)\,\mathbf{i} - \sin(kt)\,\mathbf{j}]$, where C and k are constants while t is the time.

a) Find the force acting on the object.
b) Find the impulse between $t = 0$ and $t = (\pi/2k)$.
c) Is the kinetic energy of the object constant? Support your answer with suitable calculations.

(14 marks)

A3. A square wire loop of sides 4.0 cm is in a uniform magnetic field **B** of magnitude 0.15 T.

a) What is the magnetic flux when **B** is perpendicular to the face of the loop?
b) What is the magnetic flux when **B** is at an angle of 60° to the area **A** of the loop?
c) If the angle between **B** and **A** is changed from 60° to 0° in 0.10 s, what is the magnitude of the average current in the loop if its resistance is 0.12 Ω?

(14 marks)

A4. A particle of mass 1.0 g is undergoing simple harmonic motion with an amplitude of 2.0 mm. The magnitude of its acceleration at the end of the trajectory is 8.0×10^7 m/s^2.

a) What is the angular frequency, frequency and time period?
b) What is the total energy of the particle?
c) What is the velocity of the particle when it is 1.2 mm from the equilibrium?

(14 marks)

A5. A force $\mathbf{F}(t) = (2.00t)\,\mathbf{i} + 4.00\,\mathbf{j}$ N acts on a 2.00 kg object initially at rest at the origin, where t is the time.

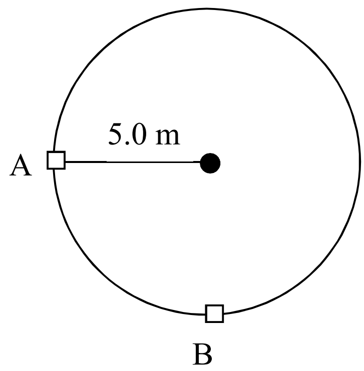
a) Determine the object's velocity in component form at $t = 1.00$ s.
b) Determine the object's position in component form at $t = 1.00$ s.
c) Determine the object's kinetic energy at $t = 1.00$ s.
d) What is the work done in the first 1.00 s?

(14 marks)

<u>Section B</u> (50 marks)

Answer all THREE questions in this section.

B1. A 1.0 kg mass A, attached to a string, is released from rest and swings in a vertical plane through an angle of 90° and strikes a 1.0 kg mass B (which is at rest) as shown. Both masses stick together on impact and move with velocity v m/s. The radius of the circle is 5.0 m.



a) What is the tension in the string immediately before the collision?
b) What is the tension in the string immediately after the collision?
c) How much kinetic energy is lost as a result of the collision?
d) Through what vertical distance will the two masses rise together?

(20 marks)

B2. A uniform electric field exists in the region between two horizontal oppositely charged plane parallel plates separated by a distance d. A positive charge q of mass m initially at rest is released from the surface of the positively charged plate and travels downwards before it strikes the opposite plate in time T. Assume that the weight of the charge is negligible.

a) Derive an expression for the electric field in terms of d, q, m and T.
b) What is the potential difference between the charged plates?
c) Calculate the velocity of the charge when it strikes the second plate.

(15 marks)

B3. A plane has a velocity $50\ \mathbf{i} + 30\ \mathbf{j}$ m/s relative to the ground. Wind is blowing at $20\ \mathbf{i} - 10\ \mathbf{j}$ m/s with respect to the ground.

a) What is the angle between the velocity vectors of the plane and the wind?
b) What is the velocity of the plane relative to the wind?
c) What is the velocity of the wind relative to the plane?

(15 marks)

***** End of Paper *****

Formula sheet

Name: ________________________ Admin. No.: _______________ Seat No.: ________

Kinematics

$$v_x = v_{0x} + a_x t$$
$$v_x{}^2 = v_{0x}{}^2 + 2a_x(x - x_0)$$
$$x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$$
$$\vec{v} = \frac{d\vec{r}}{dt}, \quad \vec{a} = \frac{d\vec{v}}{dt}$$
$$y = (\tan\theta)x - \left(\frac{g}{2v^2\cos^2\theta}\right)x^2$$
$$R = \frac{v^2 \sin 2\theta}{g}$$

Dynamics

$$\vec{F} = m\frac{d\vec{v}}{dt} = m\vec{a}, \ F = \mu N$$
$$a = \frac{dv}{dt}, \ a = \frac{v^2}{r}, F = m\frac{v^2}{r}$$
$$\vec{J} = \int \vec{F}dt = \Delta\vec{p}$$
$$W = \int \vec{F}.\,\vec{dr}, \ W_{net} = K_f - K_i$$
$$KE = \frac{1}{2}mv^2, \ PE = mgh$$
$$PE = \frac{1}{2}kx^2, P = \frac{W}{t}, \ P = \frac{dW}{dt}$$

Linear momentum

$$m_1\vec{u}_1 + m_2\vec{u}_2 = m_1\vec{v}_1 + m_2\vec{v}_2$$
$$\vec{p} = m\vec{v}$$

Static electricity

$$F = k\frac{q_1 q_2}{r^2}, \ k = \frac{1}{4\pi\varepsilon_o}$$
$$F = qE$$
$$V = k\frac{q}{r}, U = qV$$
$$V = Ed, W = qV, \ E = \frac{kq}{r^2}$$

Current electricity

$$Q = It \qquad V = IR$$
$$P = VI = I^2R = \frac{V^2}{R}$$

Magnetism & electromagnetism

$$\vec{F} = q\vec{v} \times \vec{B} \qquad \vec{F} = i\vec{L} \times \vec{B}$$
$$e.m.f. = -N\frac{d\Phi_B}{dt} = (\vec{v} \times \vec{B}) \cdot \vec{l}$$
$$\Phi_B = \vec{B} \cdot \vec{A}$$

Thermodynamics

$$\Delta U = Q - W$$
$$W = \int p\,dV$$
$Q_V = nC_V\Delta T$ const vol

$Q_p = nC_p\Delta T$ const pressure

$$Q = mC\Delta T$$
$$Q = mL$$

Ideal Gas

$$pV = nRT$$
$pV^\gamma = c$ (adiabatic)

$$\gamma = \frac{C_p}{C_V}, \ C_p - C_v = R$$
$$W = pV \ln\frac{V_2}{V_1} = nRT \ln\frac{V_2}{V_1}$$
$$W = \frac{1}{\gamma - 1}(p_1V_1 - p_2V_2)$$

Rotational Motion

$$\omega = \frac{d\theta}{dt}, \quad \alpha = \frac{d\omega}{dt}$$
$$\omega = \omega_0 + \alpha t, \ v = \omega r$$
$$\omega^2 = \omega_0{}^2 + 2\alpha(\theta - \theta_0)$$
$$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$$
$$\mathrm{I} = \sum_i^n m_i r_i^2, \ \mathrm{I} = \int r^2 dm, \ K = \frac{1}{2}I\omega^2$$

SHM & waves

$$T = \frac{1}{f} \quad v = f\lambda \quad \omega = 2\pi f$$
$$\omega = \frac{2\pi}{T} \quad k = \frac{2\pi}{\lambda}$$
$$\omega = \sqrt{k/m} \quad \omega = \sqrt{g/L}$$
$$x = A\cos(\omega t + \phi)$$
$$x = A\sin(\omega t + \phi)$$
$$y(x,t) = A\cos(\omega t \pm kx + \phi)$$
$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}$$

Circuits

$R = R_1 + R_2 + R_3 + \ldots$ series

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$ parallel

$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots$ series

$C = C_1 + C_2 + C_3 + \ldots$ parallel

$$Q = CV \qquad U = \frac{1}{2}CV^2$$

Constants

Charge on electron/proton
$e = -1.60 \times 10^{-19}$ / 1.60×10^{-19} C

Coulomb's constant
$k = 8.988 \times 10^9$ N m^2 C^{-2}

Ideal gas constant
$R = 8.314$ J mol^{-1} K^{-1}

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

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

Permeability of free space
$\mu_o = 4\pi \times 10^{-7}$ N A^{-2}

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}