National University of Computer and Emerging Sciences, Lahore Campus

Course:	Applied Physics	Course Code:	EE117
Program:	BS (CS)	Semester:	Fall 2019
Duration:	2.5 hours	Total Marks:	20 (Obj)+80(Subj)=100
Paper Date:	16-12-2019	Weight	50%
Section:	All	Page(s):	7
Exam:	Final (SUBJECTIVE)	Roll No:	
Name		Section:	

Instruction/Notes: Please write your answers within the space provided. You can use rough sheet, but that won't be marked.
Constants: $g=9.8\ m/s^2$; $\varepsilon_0 = 8.85\times10^{-12}\ C^2\cdot N^{-1}\cdot m^{-2}$; e = charge of electron/proton=1.60×10^{-19} C; mass of electron=9.11×10^{-31} kg; $\mu_0 = 4\pi\times10^{-7}$ T.m/A

Question No.	1 (Objective)	2	3	4	5	6	7	Total
Maximum Marks	20	10	20	20	10	10	10	100
Marks Obtained								

Question 2: (i) A long-jumper leaves the ground at an angle of 20.0° above the horizontal and at a speed of 11.0 m/s. How far does he jump in the horizontal direction? (Assume his motion is equivalent to that of a particle.) **[4 marks]**

$\theta = 20^\circ,\ V_i = 11\ m/s$

$x_f = (V_i \cos\theta_i)\,t$ —① 1

And

$V_{fy} = V_i \sin\theta_i - gt$ 1

$0 = 11 \sin 20 - (9.8)t$

$t = 0.384$

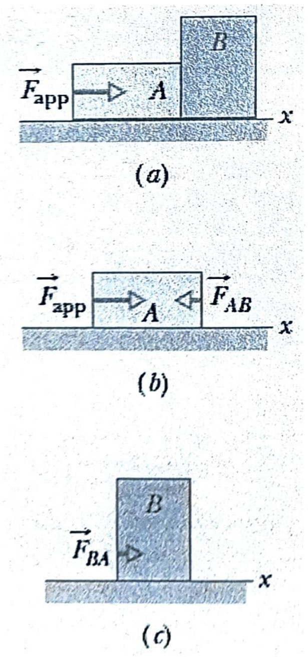
And

$T = 2t = 0.768$ 1

Eq. ① ⇒

$x_f = (11 \cos 20)(0.768)$

$\boxed{x_f = 7.94\ m}$ 1



Question 2: (ii) In Figure *a (below)*, a constant horizontal force $\boldsymbol{F_{app}}$ of magnitude 20 N is applied to block *A* of mass $\boldsymbol{m_A}$ 4.0 kg, which pushes against block *B* of mass $\boldsymbol{m_B}$ = 6.0 kg. The blocks slide over a frictionless surface, along an *x* axis.

(a) What is the acceleration of the blocks?

(b) What is the (horizontal) force $\boldsymbol{F_{BA}}$ on block *B* from block *A* (Figure c)?

[3+3=6 marks]

a) $F_{app} = m_A a$

And

$F_{app} = (m_A + m_B)a$

$a = \dfrac{F_{app}}{m_A + m_B}$ 2

$a = \dfrac{20}{4+6} = \boxed{2\ m/s^2}$ 1

b) $F_{BA} = m_B a$ 2

$= 6(2)$

$\boxed{F_{BA} = 12\ N}$ 1

Question 3 (i) A block whose mass m is 680 g is fastened to a spring whose spring constant k is 65 N/m. The block is pulled a distance x = 11 cm from its equilibrium position at x = 0 on a frictionless surface and released from rest at t = 0.

(a) What are the angular frequency, the frequency, and the period of the resulting motion?

(b) What is the amplitude of the oscillation?

[4+3=7 marks]

a) $m = 0.68$ kg

$k = 65$ N/m

$\omega = \sqrt{\frac{k}{m}}$ 2

$\omega = 9.8$ rad/s

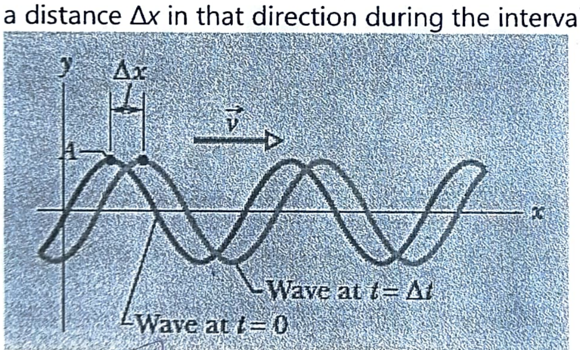
$f = \frac{\omega}{2\pi} = 1.6$ Hz 1

$T = \frac{1}{f} = 0.64$ s 1

$= 640$ ms

b) $\boxed{x_m = 11 \text{ cm}}$ 3

Question 3 (ii) Figure below shows two snapshots of the waves; they take a small time interval Δt apart. The wave is traveling in the positive direction of x (to the right in Figure), the entire wave pattern moving a distance Δx in that direction during the interval Δt. Find wave speed v. **[5 marks]**



$v = f\lambda$

$x = x_m \cos(\omega t + \phi)$

$kx - \omega t = \text{constant}$ 2

Diff. w.r.t. 't'

$k\frac{dx}{dt} - \omega = 0$

$\frac{dx}{dt} = \frac{\omega}{k}$

$\frac{\Delta x}{\Delta t} = \frac{\omega}{k}$ 2

$v = \frac{2\pi f}{2\pi/\lambda}$

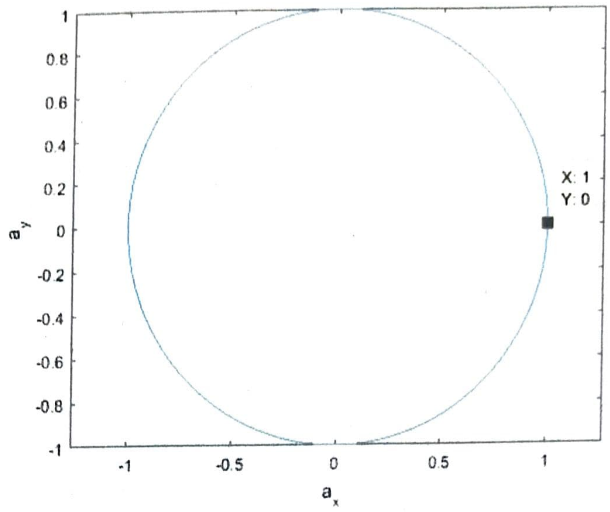
$\boxed{v = f\lambda}$ 1

FAST National University of Computer and Emerging Sciences, Lahore

Course: EE–117: Applied Physics
Session: Fall 2019

Question:

An object moves along a circular path of radius 100 m, in xy plane, with uniform speed 10 ms-1. Write a MATLAB script to plot its acceleration. Your script should reflect plot as shown in Figure below.
Hint: You may need considering this equation $\vec{a} = (-\frac{\vec{v}^2}{r}\cos\theta)\hat{\imath} + (-\frac{\vec{v}^2}{r}\sin\theta)\hat{\jmath}$



Solution:

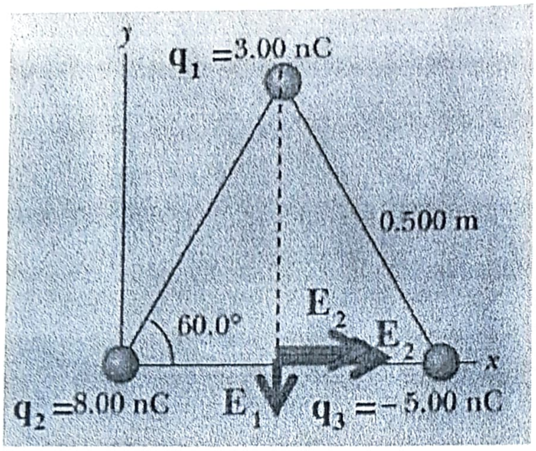
```
% Uniform Circular Motion
%% Given Information
V = 10; %    velocity 10ms-1
R=100; %     radius 100m
Theta=0:360;
%% Defining Variables
ax = -(V.^2/R)*cosd(Theta); % defining x-component of acceleration
ay = -(V.^2/R)*sind(Theta); % defining y-component of acceleration

%% Plotting variables
plot(ax,ay);
xlabel('a_x');
ylabel('a_y');
axis equal;
```

Question 4 (i) Three point charges are located at the corners of an equilateral triangle.

(a) Calculate the electric field at a point P located midway between the two charges on the x axis.

(b) If a charge of 1 nC is placed at P, determine the force (direction and magnitude) acting on this particle?

[5+5=10 marks]



a) $E_1 = k \dfrac{q_1}{r_1^2}$

r_1 is the distance from q_1 to p.

$r_1 = 0.5 \sin 60 = 0.433\,m$

$E_1 = (9\times10^9)\dfrac{3\times10^{-9}}{(0.433)^2}$

$E_1 = 144$ N/C

1.5 for E_1, E_2, E_3

And

$E_2 = k\dfrac{q_2}{r_2^2} = \dfrac{(9\times10^9)(8\times10^{-9})}{(0.250)^2}$

$E_2 = 1150$ N/C

$E_3 = k\dfrac{q_3}{r_3^2} = \dfrac{(9\times10^9)(5\times10^{-9})}{(0.250)^2}$

$E_3 = 719$ N/C.

$E = \sqrt{(E_2+E_3)^2 + E_1^2} = 1.88\times10^3$ N/C 1.5

$\theta = \tan^{-1}\dfrac{E_1}{E_2+E_3} = \tan^{-1}\left(\dfrac{-144}{1869}\right)$

$\theta = 360° - 4.4° = 355.6°$ 2

b) $F = qE$ 2

$F = (1\times10^{-9})(1.88\times10^3)$

$F = (1.88\times10^{-6}\,N)$ 1

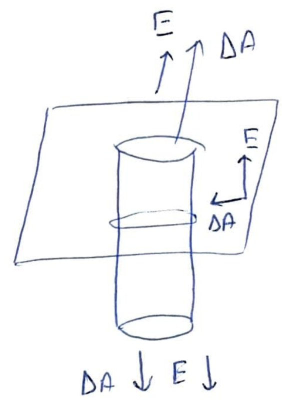
$\theta \rightarrow$ same as $\bar{E} = 355.6°$ 2

Question 4 (ii) Derive an expression of electric field from a thin, infinite, non-conducting sheet with a uniform positive surface charge density, by applying Gauss Law. **[5 marks]**

$$\varepsilon_0 \oint \bar{E}\cdot d\bar{A} = q_{enc} \qquad 1$$

$$\varepsilon_0 (EA + EA) = \sigma A$$

$$\boxed{E = \frac{\sigma}{2\varepsilon_0}} \qquad 2$$



2

Question 4 (iii) A large plane charge sheet having surface charge density σ = 2.0 × 10^{-6} C-m^{-2} lies in the X-Y plane. Find the flux of the electric field through a circular area of radius 1 cm lying completely in the region where x, y, z are all positive and with its normal making an angle of 60^0 with the Z-axis. **[5 marks]**

$\bar{E}$ near the plane charge sheet is $\frac{\sigma}{2\varepsilon_0}$ 1

So,

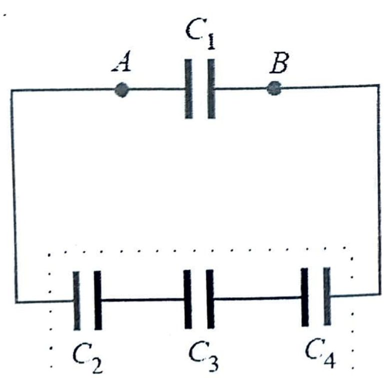
$$\phi = \bar{E}\cdot\Delta\bar{A} = E\,\Delta A\cos\theta$$

$$= \frac{\sigma}{2\varepsilon_0}(\pi r^2)\cos 60^\circ$$

$$= \frac{2\times10^{-6}}{2\times 8.85\times10^{-12}}(3.14\times10^{-4})\cdot\frac{1}{2} \qquad 3$$

$$\phi = 17.5\ \mathrm{Nm^2/C} \qquad 1$$

Question 5 (i) Figure below shows a network of four capacitors. Determine the equivalent capacitance between points A and B. If a 10V battery is connected between A and B. **[5 marks]**



$$\frac{1}{C'} = \frac{1}{C_2} + \frac{1}{C_3} + \frac{1}{C_4}$$

$$= \frac{1}{C} + \frac{1}{C} + \frac{1}{C} \qquad 2$$

$$\frac{1}{C'} = \frac{3}{C} \Rightarrow C' = \frac{C}{3}$$

$$C_{AB} = C_1 + C' = C + \frac{C}{3} \qquad 2$$

$$\boxed{C_{AB} = \frac{3+C^2}{C}}$$

$$C_{AB} = \frac{3C + C}{3} = \frac{4C}{3} \qquad 1$$

Question 5 (ii) What is the current in a wire of radius R = 3.40 mm if the magnitude of the current density is given by $J_b = J_0\ (1 - r/R)$, in which r is the radial distance and J_0 = 5.50 × 10^4 A/m²? **[5 marks]**

$$i = \int J_b\, dA \qquad 1$$

$$= \int_0^R J_0 \left(1 - \frac{r}{R}\right)(2\pi r\, dr) \qquad 1$$

$$= \frac{1}{3}\pi R^2 J_0 \qquad 2$$

$$i = \frac{1}{3}\pi\,(3.40\times10^{-3})^2 (5.50\times10^4)$$

$$\boxed{i = 0.666\ A} \qquad 1$$

Question 6 (i): An electron beam enters a crossed-field velocity selector with magnetic and electric fields of 2.0 mT and 6.0× 10^3 N/C, respectively.

(a) What must the velocity of the electron beam be to traverse the crossed fields undeflected?
(b) If the electric field is turned off, what is the acceleration of the electron beam and
(c) What is the radius of the circular motion that results?
[2+2+2=6 marks]

a)

$$V_d = \frac{E}{B} \qquad 1$$

$$V_d = \frac{6\times10^3}{2\times10^{-3}}$$

$$V_d = 3\times10^6\ m/s \qquad 1$$

b)

$$ma = qvB \qquad 1$$

$$a = \frac{qvB}{m}$$

$$= \frac{(1.6\times10^{-19})(3\times10^6)(2\times10^{-3})}{9.1\times10^{-31}}$$

$$a = 1.1\times10^{+15}\ m/s^2 \qquad 1$$

c)

$$\frac{mv^2}{r} = qvB$$

$$r = \frac{mv}{qB} \qquad 1$$

$$r = 8.5\times10^{-3}\ m \qquad 1$$

Question 6 (ii): Calculate Hall Potential for a current carrying copper strip immersed into the magnetic field (into the page). **[4 marks]**

$$V_H = Ed \quad \text{—} (1) \qquad 1$$

And

$$eE = eV_d B$$

$$E = V_d B$$

Eq. (1) =>

$$V_H = V_d B d \quad \text{—} (2) \qquad 1$$

And

$$V_d = \frac{J}{ne} = \frac{i}{neA} \qquad 1$$

Eq. (2 =>)

$$V_H = \frac{i}{neA} B d$$

As $l = \frac{A}{d} \Rightarrow \frac{d}{A} = \frac{1}{l}$

So,

$$\boxed{V_H = \frac{iB}{nel}} \qquad 2$$

Question 7 (i): Use Ampere's law and find magnetic field of a current carrying wire inside a long straight wire of circular cross section. Assume that the current density if uniformly distributed over the cross section of the wire. **[3 marks]**

$i_{enc} = \oint \bar{B} \cdot d\bar{s} = B \oint ds$

$i_{enc} = (2\pi r) B \quad \text{— (1} \quad 1$

And

$i \propto A$

So,

$$\frac{i_{enc}}{i} = \frac{\pi r^2}{\pi R^2}$$

$i_{enc} = i\left(\frac{r}{R}\right)^2 \quad 1$

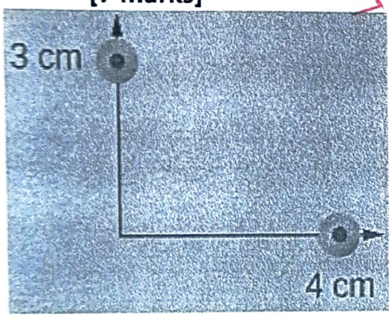
Eq. (1 ⇒

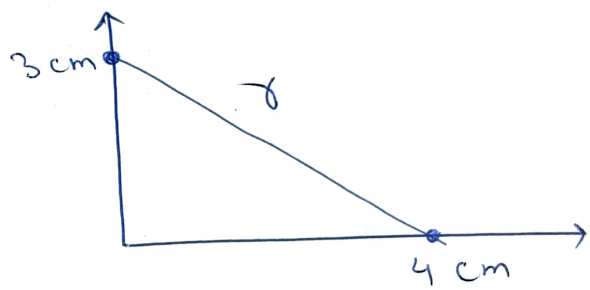
$$\boxed{B = \left(\frac{\mu_0 i}{2\pi R^2}\right) r} \quad 1$$

Question 7 (ii): Calculate magnetic forces on two wires, both are carrying currents out of the page and having a current magnitude of 5 mA. The first wire is located at (0.0 cm, 3.0 cm) while the other wire is located at (4.0 cm, 0.0 cm) as shown below.

(a) Calculate the angle between the radius and the x –axis. — 2 mark

(b) What is the magnetic force per unit length of the first wire on the second and the second on the first? Mention the answers of magnetic forces in unit-vector notation (x and y components). **[7 marks]** — 5 marks





a) $r = \sqrt{3^2 + 4^2} = 5 \text{ cm} \quad 1$

$$\frac{F}{l} = \frac{(4\pi \times 10^{-7})(5 \times 10^{-3})^2}{2\pi (5 \times 10^{-2})} = 1 \times 10^{-10} \text{ N/m}$$

$\theta = \tan^{-1}\left(\frac{3}{4}\right) = 36.9° \quad 1$

Its unit vector is

$\cos(36.9)\hat{i} - \sin(36.9)\hat{j} = 0.8\hat{i} - 0.6\hat{j} \quad 1$

b) $\frac{F}{l}$ from wire 1 on wire 2 is

$\left(\frac{F}{l}\right)_{1\to 2} = (1 \times 10^{-10})(0.8\hat{i} - 0.6\hat{j}) = (8 \times 10^{-11}\hat{i} - 6 \times 10^{-11}\hat{j}) \text{ N/m} \quad 2$

$\left(\frac{F}{l}\right)_{2\to 1} = -(8 \times 10^{-11}\hat{i} - 6 \times 10^{-11}\hat{j}) \text{ N/m} \quad 2$