National University of Computer and Emerging Sciences, Lahore Campus				
	Course:	**Applied Physics**	**Course Code:**	**EE117**
	Program:	**BS (CS), BS (DS), BS (SE)**	**Semester:**	**Fall 2020**
	Duration:	**2 hours 30 minutes**	**Total Marks:**	**20 (Obj)+80(Sub) =100**
	Date:	**08-02-2021**	**Type**	**Subjective**
	Section(s):	**All**	**Page(s):**	**15**
	Exam:	**Final**	**Roll No:**	
	Name:		**Section**	
Instructions/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 **;** $\varepsilon_0 = 8.85\times10^{-12} C^2 \cdot N^{-1} m^{-2}$ **; e = charge of electron/proton=** $1.60\times10^{-19} C$ **; mass of electron=** 9.11×10^{-31} **kg;** μ_0 **= 4π×10T.m/A**			

Question 2(a). Suppose that

$$A = i\cos(\omega t) + j\sin(\omega t)$$

where ω is a constant. Find dA/dt (note that i and j behave as constants in differentiation). Show that dA/dt is perpendicular to A. **(2+3=5 marks)**

$$\frac{d\vec{A}}{dt} = -\hat{i}\,\omega\sin(\omega t) + \hat{j}\,\omega\cos(\omega t)$$

$$\vec{A}\cdot\frac{d\vec{A}}{dt} = \omega\sin(\omega t)\cos(\omega t) - \omega\cos(\omega t)\sin(\omega t) = 0$$

Question 2(b): A golfer claims that a golf ball launched with an elevation angle of $12°$ can reach a horizontal range of 250 m. Ignoring air friction, what would the initial speed of such a golf ball have to be? What maximum height would it reach? **(3+2=5 marks)**

$$R = \frac{V_0^2 \sin(2\theta)}{g}$$

$\theta = 12°$

$R = 250m$

$$V_0 = \sqrt{\frac{Rg}{\sin(2\theta)}} = 77.7 \text{ m/s}$$

$$\text{Max. height} = H = \frac{V_0^2 \sin^2\theta}{2g} = 13.3 m$$

Question 2(c): A woman pushes horizontally on a wooden box of mass 60 kg sitting on a frictionless ramp inclined at an angle of $30°$ (see Fig. below).

(i) Draw the "free-body" diagram for the box. **(2 marks)**

(ii) Calculate the magnitudes of all the forces acting on the box under the assumption that the box is at rest or in uniform motion along the ramp. **(3 marks)**

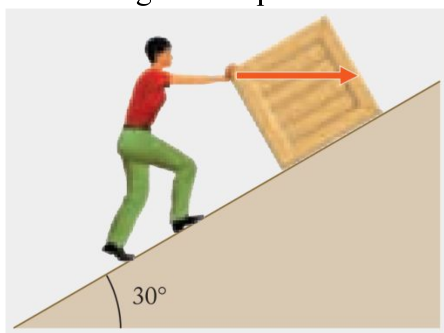


Figure for Question 1(c)

X-axis

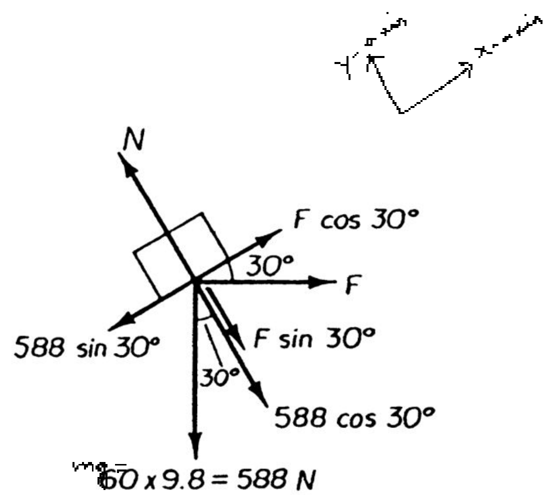
$F\cos 30° - 588\sin 30° = 0$

$F = 339.5\,N$

Y-axis

$N - F\sin 30° - 588\cos 30° = 0$

$N = 679\,N$



Question 3(a): Explain in simple words why the time-period of simple pendulum is independent of its mass. **(2 marks)**

Changing mass of pendulum changes the restoring force on pendulum at extreme position. thus accelration remains constant & time period as well.

Question 3(b) Explain why the angular amplitude θ_m of a simple pendulum should be small?**(2 marks)**

If θ_m is not small, motion will no longer be SHM.

We need assumptions to get analytical results.

Question 3(c): The equation of a wave travelling in the $+x-$direction is given as

$$y = y_m \sin sin \ (kx - \omega t + \phi)$$

(i) Explain what does each variable in above equation represent? **(3 marks)**

(ii) How the variables in above equation are related to wave speed, wavelength and time-period? **(3 marks)**

$y_m \longrightarrow$ max Amplitude.

k = Angular wave number

ω = Angular frequency!

ϕ = phase.

$v = \omega k$; $\lambda = \frac{2\pi}{k}$; $\omega = 2\pi / T$

Question4(a): Four charges of same magnitude are kept at 4 vertices of a square as shown in the figure below.

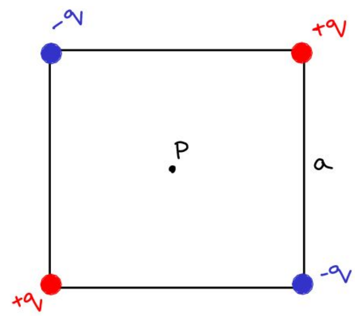


Figure for Question 3(a)

(i) Find the electric field at the center of the square i.e., at point P? **(3 marks)**

(ii) If I place a +ve charge $+Q$ at point P, what will be the magnitude and direction of the force applied on charge $+Q$? What if I place a -ve charge $-Q$ instead of $+Q$? **(1+1=2 marks)**

(i) zero All E-fields cancel eachother.

(ii) zero, still zero.

Question 4(b): Suppose you have a solid sphere of radius R with uniform volume charge density ρ. Find the electric field outside and inside the sphere. **(5 marks)**

$\vec{E}$ (outside the sphere) = ?

Let uniform charge density $= \rho$

Let radius of sphere $= R$

$$\rho = Q/\tfrac{4}{3}\pi R^3 \Rightarrow Q = \tfrac{3}{4}\rho\pi R^3$$

$$\vec{E} \text{ outside sphere} = K\frac{Q}{r^2} \qquad (r>R)$$

$$\vec{E} \text{ inside sphere} = K\frac{Qr}{R^3} \qquad (r<R)$$

Reference: P-676 of recommended book.

Question 5(a): A parallel-plate capacitor consists of two strips of aluminum foil, each with an area of $0.20\ m^2$, separated by a distance of 0.10 mm.The space between the foils is empty.The two strips are connected to the terminals of a battery, which produces a potential difference of 200 volts between them. What is the capacitance of this capacitor? What is the electric charge on each plate? What is the strength of the electric field between the plates? **(3+2+1=6 marks)**

$$C = \frac{\varepsilon_0 A}{d} = 0.018\,\mu F$$

$$Q = C\Delta V = 3.6 \times 10^{-6}\ C$$

$$E = \frac{\Delta V}{d} = 2 \times 10^{6}\ \text{volts/m}$$

Question 5(b): Six identical capacitors of capacitance C are connected as shown in Figure below. What is the net capacitance of the combination? **(4 marks)**

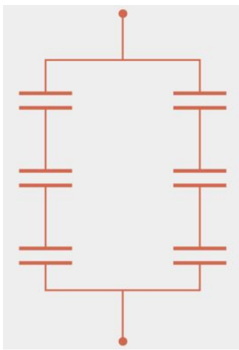


Figure for Question 4(b)
(c)\\\\\\\\\\

$$C = \left(\frac{1}{C} + \frac{1}{C} + \frac{1}{C}\right)^{-1} + \left(\frac{1}{C} + \frac{1}{C} + \frac{1}{C}\right)^{-1} = \frac{C}{3} + \frac{C}{3} = \frac{2C}{3}$$

Question 6(a): A current begins flowing into an initially uncharged capacitor at $t = 0$ and decreases to zero during $0 \le t \le 2.0$ s with a time dependence given by $I = A \times (t - 2.0\ s)^2$, where $A = 0.25\ C/s^2$. What is the initial current? The current at 1.0 s? How much charge is on the capacitor when the current stops at $t = 2.0\ s$? **(5 marks)**

The current at an elapsed time t is given by

$$I(t) = A(t-2)^2 = 0.25(t-2)^2 \text{ A}$$

$$I(t=0s) = 1\text{A}$$

$$I(t=1s) = 0.25\text{ A}$$

$$(\text{Total charge})\ Q = \int_0^2 I(t)\,dt = \int_0^2 A(t-2)^2\,dt = \frac{2}{3}\ C \longrightarrow \text{coulombs}$$

Question 6(b): The magnitude J of the current density in a certain lab wire with a circular cross section of radius $R = 2.00$ mm is given by $J = (3.00 \times 10^8)r^2$, with J in amperes per square meter and radial distance r in meters. What is the current through the outer section bounded by $r = 0.900\,R$ and $r = R$?

(5 marks)

$$i = \int_{0.9R}^{R} J\,dA = \int_{0.9R}^{R} (kr^2)\,2\pi r\,dr = \frac{1}{2} k\pi \left(R^4 - 0.656\,R^4\right)$$

As $R = 0.002\,m$; $i = 2.59 \times 10^{-3}\,A$.

Question 6(c): Suppose a current i is flowing through a uniform cylindrical conducting wire. Derive an expression of drift velocity in terms of i, A, n and e. Here, i is the current, A is area of cross-section of cylindrical wire, n is number of charge carriers per unit volume and e is the charge on an electron **(5 marks)**

$q = Ne$ —(1)

$n = \frac{N}{AL}$ (No. of charge carrier per unit vol).

$N = nAL\cancel{e}$ —(2)

Put in eq (1)

$q = Ne$

$q = (nALe)$ —(3)

The total charges moves through any ~~cross~~ s cross section in the time intervel t.

$t = \frac{L}{V_d}$ —(4) ($\because s = vt \Rightarrow t = s/v$)

$i = \frac{q}{t} \Rightarrow \frac{q}{L/V_d} = \frac{nALeV_d}{L}$ (From eq 3 and 4)

$$\boxed{V_d = \frac{i/A}{ne}}$$

Question 7(a): Derive an expression of angular frequency of a charged particle rotating in a uniform magnetic field. **(5 marks)**

$$F = ma_c$$

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

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

$$r = \frac{mv}{qB} \quad — (1)$$

$$T = \frac{S}{v} = \frac{2\pi r}{v} \;(3) \Rightarrow \frac{2\pi(mv)}{qBv} = \frac{2\pi m}{qB} \;(2) \;(\text{From eq } (1))$$

$$f = \frac{1}{T} = \frac{qB}{2\pi m} \;(\text{from eq } (2))$$

$$\omega = 2\pi f = \frac{qB}{m} \;(\text{from } (3)).$$

Question 7(b):A straight, horizontal length of copper wire has a current $i = 28$ A through it. What are the magnitude and direction of the minimum magnetic field needed to suspend the wire—that is, to balance the gravitational force on it? The linear density (mass per unit length) of the wire is 46.6 g/m.

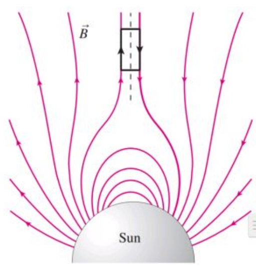
(5 marks)

$$iLB\sin\phi = mg$$

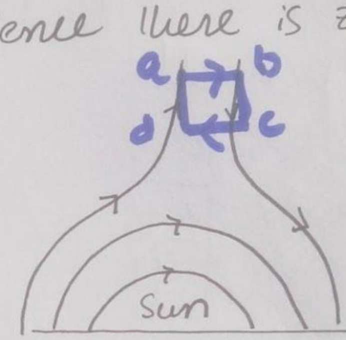
$$B = \frac{mg}{iL\sin\phi} = \frac{g(m/L)}{i\sin\phi}$$

$$B = 1.6\times10^{-2}\ T$$

Question 8(a): The long dimension of the rectangular loop in Figure is 400 ×106 m, and the magnetic fieldstrength near loop has constant magnitude of 2 mT. Use mathematical form of the Ampere's law to estimate the total current encircled by the rectangle.



In the side "ab" and "cd" $\bar{B} \perp d\bar{r}$, Hence there is zero contribution due to these sides.



$\vec{B}$ is constant in "bc" and "ad" and lies in the direction of Amperian loop.

So here,

$$\oint \bar{B}\cdot d\bar{r} = 2Bl \quad \text{(for both long sides).}$$

$$I_{enc} = \frac{2Bl}{\mu_0} = \frac{(2)(2mT)(400\times10^{6}m)}{4\pi\times10^{-7}\,N/A^2} = 10^{12}\,A.$$

Question 8(b): A long solenoid has 100 turns/cm and carries current i. An electron moves within the solenoid in a circle of radius 2.30 cm perpendicular to the solenoid axis. The speed of the electron is $0.0460c$ (c speed of light). Find the current i in the solenoid. **(5 marks)**

Orbital radius of e^- is:

$$r = \frac{mv}{eB} = \frac{mv}{e\mu_0 n i}$$

$$i = \frac{mv}{e\mu_0 n r} = 0.272 \text{ A}$$