Name: 190123046 Roll No:

Mid-Semester Examination PHYSICS II: PH102 March 2, 2020



Indian Institute of Technology Guwahati Guwahati, India - 781031

Please read the instructions carefully

- a) Write your name and roll number on each page. There is a total of three sheets in this booklet.
- b) All questions are compulsory.
- c) You must write all parts of the answers in the space provided for the given questions.
- d) Write only the final answer in this booklet. There is no partial credit for intermediate steps leading to the final answer.
- e) You must write the final answer only in the space provided for the given question. Answers written outside the box will not be evaluated. It is advised that you solve the problems in the rough book (usual answer book) and then copy the final answer in the space provided for that problem.

Useful Formulas

Divergence in spherical coordinates: $\vec{\nabla} \cdot \vec{A} = \frac{1}{r^2} \frac{\partial}{\partial r} (r^2 A_r) + \frac{1}{r \sin \theta} \frac{\partial}{\partial \theta} (A_{\theta} \sin \theta) + \frac{1}{r \sin \theta} \frac{\partial A_{\phi}}{\partial \phi}$.

Divergence in cylindrical coordinates: $\vec{\nabla} \cdot \vec{V} = \frac{1}{s} \frac{\partial}{\partial s} (sV_s) + \frac{1}{s} \frac{\partial V_{\phi}}{\partial \phi} + \frac{\partial V_z}{\partial z}$.

Hyperbolic function: $\sinh x = \frac{1}{2}(e^x - e^{-x}), \cosh x = \frac{1}{2}(e^x + e^{-x}).$

Examiner's Signature

Student's Signature

Invigilator's Signature

2 - 4 PM

Name: Prod Desh 190123046 Roll No:

This question contains two parts; Write only the final answers of them in the corresponding space provided.

(a) Find the values of x where the Dirac-delta function $\delta(\sin x)$ is non-vanishing. |1|

Answer: 2 = NT, NEZ (integers

(b) Using the formula $\delta(y(x)) = \sum_{i} \frac{\delta(x - x_i)}{\left|\frac{dy}{dx}\right|_{x = x_i}}$, where x_i is the i^{th} root of y(x) = 0, evaluate

$$\int_{-\infty}^{+\infty} dx \ \delta(\sin x) \ e^{-|x|} \ .$$

[2]

Answer:

Consider an electric displacement vector $\vec{D} = zs\cos^2\phi\hat{z}$ units in cylindrical coordinates in some region of space. Determine the following:

(a) The free volume charge density at any point.

|1|

Answer:



(b) The total free volume charge enclosed within the cylinder of radius 1 unit with $-2 \le z \le 2$ units.

Answer:



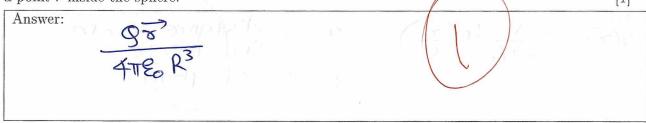


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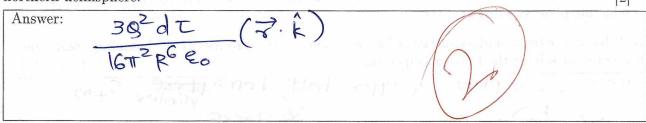
Name:	sad	nes	h	P.	Ka	Kar	
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Question 3: This question consists of three parts. Write only the final answers at the respective spaces.

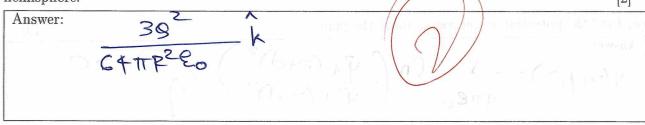
a) Consider a uniformly charged sphere of radius R with total charge Q. Find the electric field at a point \vec{r} inside the sphere.



b) Determine the z-component of the force on a volume element $d\tau$ at any position \vec{r} in the northern hemisphere.



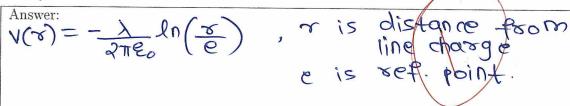
c) Using the above results find the net force that the southern hemisphere exerts on the northern hemisphere.



Name: Kalkas Roll No: 0123046

Question 4: This question consists of two parts. Write only the final answers at the respective spaces.

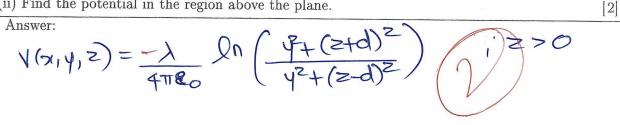
a) Find the potential in the vicinity of an infinite straight line charge with uniform line charge density λ .



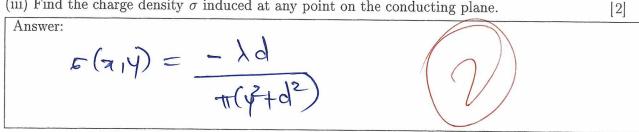
- b) The above infinite straight line charge is placed at a distance d above an infinite grounded conducting plane. Let's say that the wire runs parallel to x-axis, directly above the grounded conducting plane situated at z = 0.
- (i) What is/are the boundary surface/s for the region z > 0? Also specify the boundary conditions necessary for solving the Poisson's equation.



(ii) Find the potential in the region above the plane.



(iii) Find the charge density σ induced at any point on the conducting plane.



Name: Pradnesh P. Kalkar Roll No: 190123046

Question 5: This question consists of three parts. Write only the final answers at the respective spaces.

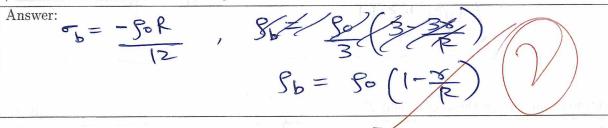
Consider an uncharged polarized dielectric sphere of radius R with "frozen in" polarization

$$\vec{P} = -\frac{\rho_0}{3} \Big(1 - \frac{3r}{4R} \Big) \vec{r} ,$$

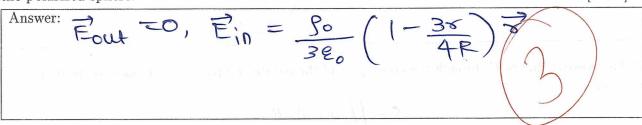
where ρ_0 is a positive constant. Find the following:

a) Surface and volume bound charge densities.

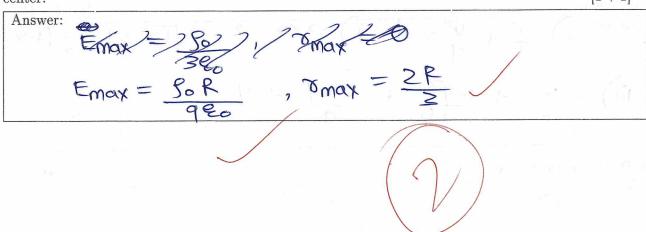
[1 + 1]



b) Magnitude of the electric fields as a function of distance from the center, both <u>inside</u> and <u>outside</u> the polarized sphere. [1+2]



c) The maximum value of the electric field $E_{\rm max}$ and the corresponding distance $r_{\rm max}$ from the center. [1+1]

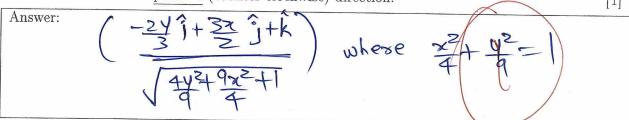


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Question 6: This question consists of four parts. Write only the final answers at the respective spaces.

Consider a vector field $\vec{F} = z\hat{i} + x\hat{j} + y\hat{k}$, and the part of the paraboloid, $z = \frac{x^2}{4} + \frac{y^2}{9}$, such that $z \le 1$.

a) Find the unit vector on the <u>curved</u> surface of the paraboloid corresponding to traversing its contour at z = 1 in the <u>positive</u> (counter clockwise) direction.



b) Determine the curl of the vector field \vec{F} .







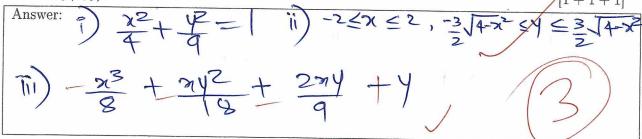
|0.5|

c) The positive flux of \vec{F} through the above part of the paraboloid may be expressed as the double integral

$$\Phi = \iint_{\mathcal{R}} g(x, y) \ dR,$$

where R is the projection of the paraboloid on the xy-plane.

Determine (i) the equation of the region \mathcal{R} , (ii) the limits of the above flux integral, and (iii) the function g(x,y).



d) Determine the flux Φ .

Answer:



 $\lfloor 1.5 \rfloor$

