

Physics 385
Electromagnetism

Fall 2005 - Prof. Bartynski

Exam II

Friday, 18-November-2005

1:40 PM – 3:00 PM

Closed Book. Closed Notes.
Calculator OK, Two Cheat Sheets OK.

Do not open this exam until instructed to do so.
Please fill out the information on the cover of your blue book.
Answer all 4 problems.

Possibly useful information:

$$P_0(\cos \theta) = 1;$$

$$P_1(\cos \theta) = \cos \theta;$$

$$P_2(\cos \theta) = \frac{1}{2}(3 \cos^2 \theta - 1);$$

$$P_3(\cos \theta) = \frac{1}{2}(5 \cos^3 \theta - 3 \cos \theta)$$

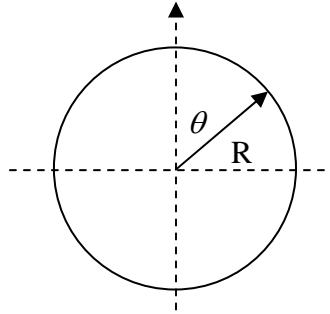
$$\int P_l(\cos \theta) P_{l'}(\cos \theta) \sin \theta d\theta = \frac{2}{2l+1} \delta_{l,l'}$$

$$\cos 2\theta = (2 \cos^2 \theta - 1)$$

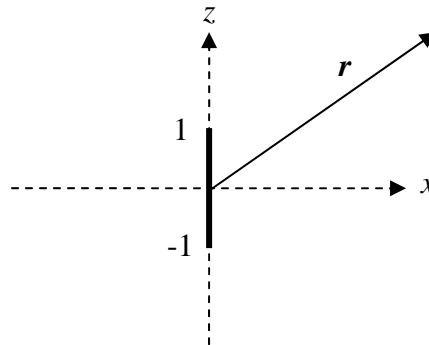
Binomial expansion: $(1+x)^n = 1 + nx + \frac{n(n-1)}{2!}x^2 + \dots$ where $x^2 < 1$

Some useful constants: $e = 1.6 \times 10^{-19} \text{ C}$; $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2$

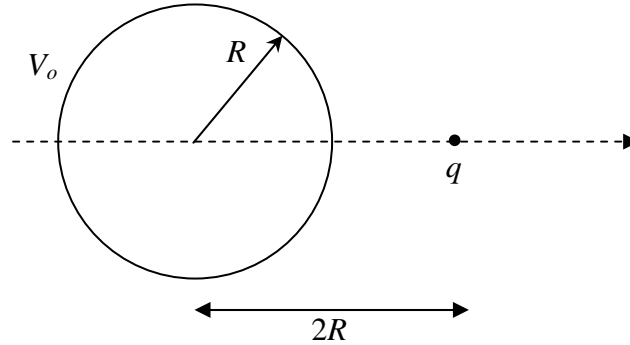
- 25 pts 1) The potential on a thin spherical shell of radius R is fixed at $V_0 \cos(2\theta)$. Find expressions for the potential in the regions $r \leq R$ and $r \geq R$?



- 25 pts 2) A linear charge distribution along the z -axis is given by $\lambda_1(z) = k(z^3 - z)$ for $-1 < z < 1$; $\lambda(z) = 0$ otherwise.
- Find the monopole, dipole and quadrupole moments of this charge distribution.
 - Find an expression for the potential for large r . What does large r mean?
 - Suppose instead that the charge distribution was $\lambda_2(z) = (5z^3 - 3z)$ for $-1 < z < 1$; $\lambda(z) = 0$ otherwise. At large r , the potential will go as $V(r) = V_n \left(\frac{1}{r^n}\right)$ to leading order. What is n in this case?



- 25 pts 3) A point charge, q , is a distance $2R$ from the center of a conducting sphere of radius R . The sphere is maintained at a constant potential V_o . Find the potential for $r > R$.



- 25 pts 4) A spherical conducting shell of radius a carries a net charge q . The conductor is surrounded by a concentric thick spherical shell of a dielectric with susceptibility χ_e of inner radius b and outer radius c , as shown in the figure below.

- (a) Determine the electric field in all regions of space (*i.e.*, $r < a$, $a < r < b$, $b < r < c$; and $d < r$).
- (b) Find the charge density on each surface and in the volume of the dielectric. Indicate whether the charge density is free or bound. [Recall

$$\vec{\nabla} \cdot \left(\frac{\hat{\mathfrak{R}}}{\mathfrak{R}^2} \right) = 4\pi\delta(\vec{r}) \text{ where } \vec{\mathfrak{R}} = \vec{r} - \vec{r}']$$

