**BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI (RAJASTHAN)**

**2017 - 2018 (SEMESTER I)**

**Electromagnetic Theory I (PHY F212)**
**Mid-Semester Examination (Closed Book)**
**12th October 2017**

**Max. Marks : 60** **Duration : 1 hr 30 mins**

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1. Evaluate the integral:

$$A = \int_V \left(\frac{1}{r-2}\right) \nabla^2 \left(\frac{1}{r^2}\right),$$

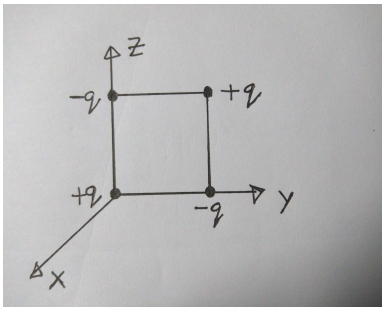
where $V$ is the sphere of radius 2 centred at point $P(1,1,1)$.

**[5]**

2. (i) (a) Find the repulsive force between the '*northern*' and the '*southern*' hemispheres of a uniformly charged insulating solid sphere of radius $R$ and total charge $Q$.
   (b) If the insulating sphere is replaced by a conducting one, what will be the repulsive force between the '*northern*' and the '*southern*' hemispheres?
   (ii) Find the capacitance of two concentric spherical shells of radii $a$ and $b$?

**[(12+8)+5]**

3. Four point charges are placed at the corners of a square of side $a$ as shown in the figure.




(i) <u>*Explicitly*</u> derive the first three terms $(n = 0,1,2)$ in the multipole expansion for the potential.

**Given:** $V(\vec{r}) = \frac{1}{4\pi\varepsilon_0}\left[\frac{1}{r}\int \rho(\vec{r}')\,d\tau' + \frac{1}{r^2}\int r'\cos\alpha\,\rho(\vec{r}')\,d\tau' + \frac{1}{r^3}\int (r')^2\left(\frac{3}{2}\cos^2\alpha - \frac{1}{2}\right)\rho(\vec{r}')\,d\tau' + \ldots\right]$

(ii) Two point charges $q_1$ and $q_2$ are placed at distances $a$ and $b$, respectively, from the origin. Calculate the average potential over a spherical surface of radius $R$, centered at the origin (where $a < R < b$).

**[12+8]**

4. A point charge $q$ is situated at a large distance $r$ from a neutral atom of polarizability $\alpha$. Find the force on the point charge due to the neutral atom.

**[10]**