Question 1: A thin insulating rod is bent into a semicircle of radius $R$. The upper and lower halves of the semicircle carry uniform linear charge densities, $-\lambda$ and $+\lambda$, respectively. (i) Find the electric potential, $V$, at the center of the semicircle. (ii) Find the electric field vector, $\mathbf{E}$, at the center of the semicircle.

Question 2: The center of a cube of side $a$ is located at the origin, as shown in the Figure. The electric field is given by
$$\mathbf{E} = E_0 \hat{i} + \frac{C}{r^2} \hat{r},$$
where $E_0$ and $C$ are positive constants, and $r$ is the radial distance from the origin $O$. Calculate the electric flux through the entire surface of the cube.

Question 3: A slab of insulating material has a uniform positive charge density $\rho$. The width of the slab is $d$, and its median plane is located at $x = 0$. The slab is infinite in the $y$ and $z$ directions. (See Figure.) Calculate the electric field in (i) the exterior region, $|x| > d/2$, and (ii) the interior region, $0 \leq |x| < d/2$.

Question 4: An insulating spherical shell of radius $R$ carries a positive charge $Q$, uniformly distributed over its surface. The center of the sphere is located at $(R, 0)$. Find the minimum work necessary to take a positive point charge $q$ from the initial point $A: (4R, 0)$ to the final point $B: (0, 0)$ along the semicircular path of radius $2R$, shown in the Figure.

Question 5: An air-filled parallel-plate capacitor has plates of area $A$, separated by a distance $d$. The capacitor is isolated and has charges $+Q$ and $-Q$ on its plates. Calculate the work necessary to increase the plate separation to $7d$.

Question 6: A spherical capacitor consists of a spherical conducting shell of radius $b$ and charge $-Q$, concentric with a smaller conducting sphere of radius $a$ and charge $+Q$. The space between the sphere and the shell is filled with a dielectric material of dielectric constant $\kappa$. (See Figure.) Find the capacitance of this device.