Prb. #	ANSWERS
1	For a uniform electric field passing through a plane surface, $\Phi_E = \vec{\mathbf{E}} \cdot \vec{\mathbf{A}} = EA\cos\theta$, where θ is the angle between the electric field and the normal to the surface. (a) The electric field is perpendicular to the surface, so $\theta = 0°$: $\Phi_E = (6.20\times10^5\ \text{N/C})(3.20\ \text{m}^2)\cos 0°$ $\Phi_E = \boxed{1.98\times10^6\ \text{N}\cdot\text{m}^2/\text{C}}$ (b) The electric field is parallel to the surface: $\theta = 90°$, so $\cos\theta = 0$, and the flux is $\boxed{\text{zero.}}$ Note: values of E & A may vary.
2	For a uniform field the flux is $\Phi = \vec{\mathbf{E}} \cdot \vec{\mathbf{A}} = EA\cos\theta$. The maximum value of the flux occurs when $\theta = 0$, or when the field is in the same direction as the area vector, which is defined as having the direction of the perpendicular to the area. Therefore, we can calculate the field strength at this point as $E = \frac{\Phi_{max}}{A} = \frac{\Phi_{max}}{\pi r^2}$ $E = \frac{5.20\times10^5\ \text{N}\cdot\text{m}^2/\text{C}}{\pi(0.200\ \text{m})^2} = 4.14\times10^6\ \text{N/C} = \boxed{4.14\ \text{MN/C}}$ Note: values of Phi_max & r may vary.
3	The electric flux through each of the surfaces is given by $\Phi_E = \frac{q_{in}}{\epsilon_0}$. Flux through S_1: $\Phi_E = \frac{-2Q+Q}{\epsilon_0} = \boxed{-\frac{Q}{\epsilon_0}}$ Flux through S_2: $\Phi_E = \frac{+Q-Q}{\epsilon_0} = \boxed{0}$ Flux through S_3: $\Phi_E = \frac{-2Q+Q-Q}{\epsilon_0} = \boxed{-\frac{2Q}{\epsilon_0}}$ Flux through S_4: $\Phi_E = \boxed{0}$
4	The total flux through the surface of the cube is $\Phi_E = \frac{q_{in}}{\epsilon_0} = \frac{170\times10^{-6}\ \text{C}}{8.85\times10^{-12}\ \text{C}^2/\text{N}\cdot\text{m}^2} = 1.92\times10^7\ \text{N}\cdot\text{m}^2/\text{C}$ (a) By symmetry, the flux through each face of the cube is the same. $(\Phi_E)_{\text{one face}} = \frac{1}{6}\Phi_E = \frac{1}{6}\frac{q_{in}}{\epsilon_0}$ $(\Phi_E)_{\text{one face}} = \frac{1}{6}\left(\frac{170\times10^{-6}\ \text{C}}{8.85\times10^{-12}\ \text{C}^2/\text{N}\cdot\text{m}^2}\right) = \boxed{3.20\times10^6\ \text{N}\cdot\text{m}^2/\text{C}}$ (b) $\Phi_E = \frac{q_{in}}{\epsilon_0} = \left(\frac{170\times10^{-6}\ \text{C}}{8.85\times10^{-12}\ \text{C}^2/\text{N}\cdot\text{m}^2}\right) = \boxed{1.92\times10^7\ \text{N}\cdot\text{m}^2/\text{C}}$ (c) The answer to part (a) would change because the charge could now be at different distances from each face of the cube. The answer to part (b) would be unchanged because the flux through the entire closed surface depends only on the total charge inside the surface. Note: values q and side length may vary.

5	Consider as a gaussian surface a box with horizontal area A, lying between 500 and 600 m elevation. From Gauss's Law, $$\oint \vec{\mathbf{E}} \cdot d\vec{\mathbf{A}} = \frac{q}{\epsilon_0}:$$ $$(+120\ \text{N/C})A + (-100\ \text{N/C})A = \frac{\rho A(100\ \text{m})}{\epsilon_0}$$ $$\rho = \frac{(20.0\ \text{N/C})(8.85\times10^{-12}\ \text{C}^2/\text{N}\cdot\text{m}^2)}{100\ \text{m}} = \boxed{1.77\times10^{-12}\ \text{C/m}^3}$$ The charge is $\boxed{\text{positive}}$, to produce the net outward flux of electric field. Note: values of A and E may vary.
6	For a large uniformly charged sheet, $\vec{\mathbf{E}}$ will be perpendicular to the sheet, and will have a magnitude of $$E = \frac{\sigma}{2\epsilon_0} = 2\pi k_e \sigma$$ $$= (2\pi)(8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(9.00\times10^{-6}\ \text{C/m}^2)$$ so $\vec{\mathbf{E}} = 5.08\times10^5\ \text{N/C}\ \hat{\mathbf{j}}$ Note: value of sigma may vary. Take the positive j direction to be upward.
7	(a) The electric field is given by $$E = \frac{2k_e\lambda}{r} = \frac{2k_e(Q/\ell)}{r}$$ Solving for the charge Q gives $$Q = \frac{Er\ell}{2k_e} = \frac{(3.60\times10^4\ \text{N/C})(0.190\ \text{m})(2.40\ \text{m})}{2(8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C})} =$$ $$Q = +9.13\times10^{-7}\ \text{C} = \boxed{+913\ \text{nC}}$$ (b) Since the charge is uniformly distributed on the surface of the cylindrical shell, a gaussian surface in the shape of a cylinder of 4.00 cm in radius encloses no charge, and $\vec{\mathbf{E}} = \boxed{0}$. Note: values of L and r may vary.
8	(a) At the center of the sphere, the total charge is zero, so $$E = \frac{k_e Q r}{a^3} = \boxed{0}$$ (b) At a distance of 10.0 cm = 0.100 m from the center, $$E = \frac{k_e Q r}{a^3} = \frac{(8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C})(26.0\times10^{-6}\ \text{C})(0.100\ \text{m})}{(0.400\ \text{m})^3}$$ $$= \boxed{365\ \text{kN/C}}$$ (c) At a distance of 40.0 cm = 0.400 m from the center, all of the charge is enclosed, so $$E = \frac{k_e Q}{r^2} = \frac{(8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C})(26.0\times10^{-6}\ \text{C})}{(0.400\ \text{m})^2}$$ $$= \boxed{1.46\ \text{MN/C}}$$ (d) At a distance of 60.0 cm = 0.600 m from the center, $$E = \frac{k_e Q}{r^2} = \frac{(8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C})(26.0\times10^{-6}\ \text{C})}{(0.600\ \text{m})^2}$$ $$= \boxed{649\ \text{kN/C}}$$ The direction for each electric field is $\boxed{\text{radially outward}}$. Note: distance given in part (d) may vary, along with charge.