Physics 161
Exam 2
MONDAY, OCTOBER 27, 2008

Directions: The exam consists of two parts. The first is multiple choice and is worth 85%. In the second part you are to solve two problems; here it is important to show your work/thoughts. The second part is worth 15%. There is a bonus question worth an additional 5%.

Useful information:
mass of proton 1.67×10^{-27} kg
mass of electron 9.1×10^{-31} kg
$\frac{1}{4\pi\epsilon_0} = 9\times10^9$ Nm^2/C^2
proton's charge 1.6×10^{-19} C
electron's charge -1.6×10^{-19} C
The prefix n means "nano", and stands for a factor of 10^{-9}
$\oint \vec{E}\cdot d\vec{A} = \frac{q_{\text{enclosed}}}{\epsilon_0}$

Part 1

(1) Which of the following is true?
(a) Lines of equipotential are perpendicular to the surface of a conductor.
(b) Lines of equipotential are perpendicular to lines of electric field.
(c) Lines of electric field are perpendicular to the surface of a conductor.

(2) Positive charge is distributed uniformly on an infinite planar surface. Which of the following is true for a point a distance h above the plane?
(a) The electric field decreases with distance from the surface as $1/h$.
(b) The electric field decreases with distance from the surface as $1/h^2$.
(c) The electric field decreases with distance from the surface as $1/h^3$.
(d) The electric field is constant, independent of the distance above the surface.

(3) Positive charge is distributed uniformly on the surface of an infinitely long cylinder. Which of the following is true for a point at a radius r, outside of the cylinder?
(a) The electric field is constant, independent of r.
(b) The electric field decreases with distance as $1/r$.
(c) The electric field decreases with distance as $1/r^3$.
(d) The electric field decreases with distance as $1/r^4$.

(4) A proton having a charge of 1.6×10^{-19} Coulombs is pushed from point A to point B by an electric field. Point A is at a potential of 10 volts. Point B is at a potential of 5 volts. How much work is done on the charge by the field?
(a) 6×10^{-19} J.
(b) 7×10^{-19} J.
(c) 8×10^{-19} J.
(d) 9×10^{-19} J.

(5) A test charge q is moved between two points, the initial point located at $\vec{r}_i$ and the final point located at $\vec{r}_f$. If the change in *electrical potential energy* is given by

$$\Delta U = -\int_{\vec{r}_i}^{\vec{r}_f} \vec{F} \cdot d\vec{s},$$

then the change in the *electrical potential* is given by

(a) $\Delta V = +\Delta U$

(b) $\Delta V = -\int_{\vec{r}_i}^{\vec{r}_f} \vec{E} \cdot d\vec{s}$

(c) $\Delta V = -\int_{\vec{r}_i}^{\vec{r}_f} \vec{F} \cdot d\vec{s}$

(d) $\Delta V = +\int_{\vec{r}_i}^{\vec{r}_f} \vec{E} \cdot d\vec{s}$

(6) A proton having charge 1.6×10^{-19} C is placed in an electric field. If it experiences a force of 8×10^{-15} N, what is the strength of the electric field?

(a) 20,000 N/C.

(b) 30,000 N/C.

(c) 40,000 N/C.

(d) 50,000 N/C.

(7) The principle of superposition of electrical forces states that

(a) the electric flux through a surface is the dot product of the electric field $\vec{E}$ and the surface vector $\vec{A}$.

(b) the electric field is zero inside of a conductor.

(c) the force due to many point charges may be calculated by adding up the forces due to each point charge separately.

(d) electrical forces cannot be determined when more than two point particles are interacting.

(8) A metal object is charged. Which statement is true in equilibrium?

(a) The electrical potential at the center of the metal is higher than the electrical potential at the surface.

(b) The excess charge distributes itself uniformly throughout the metal.

(c) The electric field inside the metal is constant.

(d) The excess charge resides on the surface of the metal.

(9) The electric field $\vec{E}$ at a distance r from a point charge q is best described by the following:

(a) $\vec{E} = \frac{q}{4\pi\epsilon_0 r}\hat{r}$

(b) $\vec{E} = \frac{q}{4\pi\epsilon_0 r^2}\hat{r}$

(c) $\vec{E} = \frac{q}{4\pi\epsilon_0 r^3}\hat{r}$

(d) $\vec{E} = \frac{q}{4\pi\epsilon_0 r^4}\hat{r}$

(10) An electron and a proton are separated from one another by 2×10^{-11} m, forming a dipole. What is the magnitude of the dipole moment?

(a) 1.2×10^{-30} C m

(b) 2.2×10^{-30} C m

(c) 3.2×10^{-30} C m

(d) 4.2×10^{-30} C m

(11) A uniform electric field has a strength $\vec{E}$ = 2 N/C $\hat{x}$+1 N/C $\hat{y}$. Consider a square surface with area vector $\vec{A}$ = 2 m^2 $\hat{x}$ + 2 m^2 $\hat{y}$. What is the magnitude of the electric flux through this surface?

(a) 0 Nm^2/C

(b) 1 Nm^2/C

(c) 4 Nm^2/C

(d) 6 Nm^2/C

(12) The electric potential at a distance r from a point charge q is given by
(a) $V(r) = \frac{q}{4\pi\epsilon_0 r}$
(b) $V(r) = \frac{q}{4\pi\epsilon_0 r^2}$
(c) $V(r) = \frac{q}{4\pi\epsilon_0 r^3}$
(d) $V(r) = \frac{q}{4\pi\epsilon_0 r^4}$

(13) A metal object is charged. In equilibrium, the electric field lines just outside the surface,
(a) do not exist.
(b) are tangent to the surface of the metal.
(c) are perpendicular to the surface of the metal
(d) are parallel to the equipotential surfaces.

(14) A spherical metal shell with radius R is placed in a uniform electric field E. Inside the shell, in equilibrium, the magnitude of the field is
(a) 0
(b) $\frac{1}{2}E$
(c) $4\pi E$
(d) $E/4\pi$

(15) What is the electrical force of repulsion between two electrons that are separated by a distance of 1.0 m?
(a) 2.3×10^{-28} N
(b) 2.0×10^{-28} N
(c) 1.7×10^{-28} N
(d) 1.4×10^{-28} N

(16) An electron and a proton are at rest. The distance between them is 1 nm. What is the minimum amount of work that must be performed to pull the two particles apart (to infinity)?
(a) 1.6×10^{-19} J
(b) 2.0×10^{-19} J
(c) 2.3×10^{-19} J
(d) 2.9×10^{-19} J

(17) A charge of 1 nC is transferred to a metal sphere of radius 10 cm. What is the strength of the electric field at a point outside of the sphere, 40 cm from the center of the sphere?
(a) 64 N/C.
(b) 56 N/C.
(c) 44 N/C.
(d) 38 N/C.

(18) A spherical shell of radius 10 cm is uniformly charged so that charge density on the surface is 1 nC/m^2. What is the magnitude of the electric field at a point *inside* the shell at a radial distance 5 cm from the center?
(a) 113 N/C
(b) 57 N/C
(c) 28 N/C
(d) 0 N/C

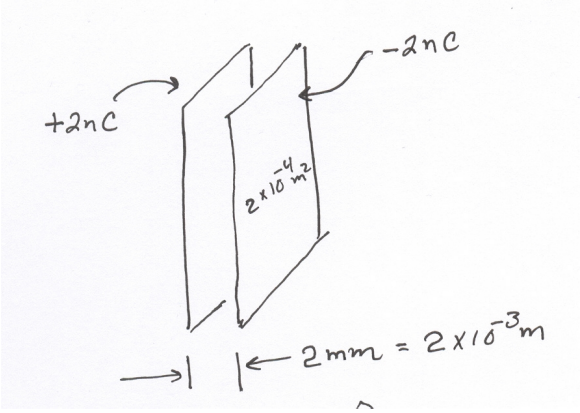
(19) The net electric flux exiting a Gaussian surface is 72π Nm^2/C^2. How much charge is enclosed by the surface?
(a) 2 nC
(b) 1 nC
(c) 3 nC
(d) 4 nC

(20) A metal sphere of radius 0.500 m is uniformly charged with negative charges so that the surface charge density is -3.2 nC/m^2. How many excess electrons are on the sphere?

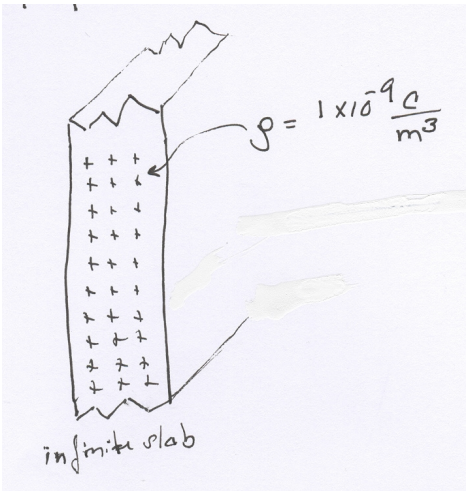
(a) 3.01×10^{10}
(b) 3.28×10^{10}
(c) 6.3×10^{10}
(d) 6.02×10^{10}

Part 2

(1-10pts) A parallel plate capacitor consists of two parallel conducting plates, each having an area 2×10^{-4} m^2. The capacitor is charged so that one plate has a charge of 2 nC, and the other plate has charge of -2 nC. If the perpendicular separation between the two plates is 2 mm, what is the difference in potential between them?



(2-5pts) A non-conducting planar slab of infinite extent has a thickness of 1 cm. Charge is distributed uniformly throughout its volume, with a density of 1 nC/m^3. What is the electric field at a point outside (external to) the slab?



(3-Bonus: 5pts) Two closely spaced parallel metal plates (i.e. a parallel plate capacitor) are charged. One of the plates has 1 nC of excess charge. In equilibrium, this is arranged such that 1/4 of the charge is uniformly distributed on the outer surface, and the remaining 3/4 of the charge is uniformly distributed on the inner surface. What is the charge q_R on the inner surface of the other plate? What is the charge q_L on its outer surface?