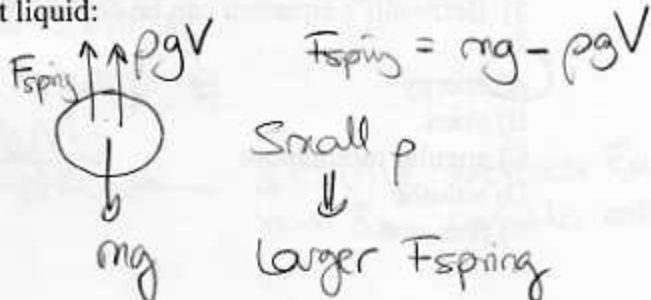


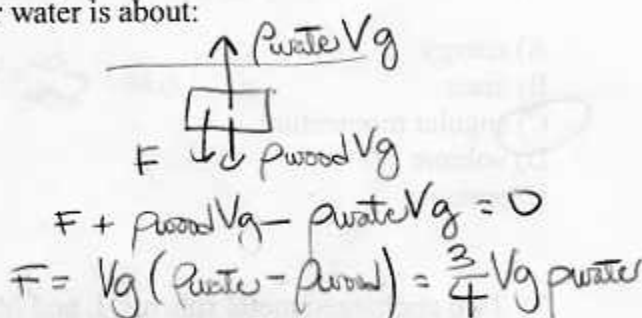
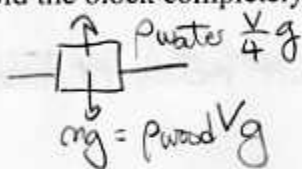
1) The apparent weight of a steel sphere immersed in various liquids is measured using a spring scale. The greatest reading is obtained for that liquid:

- A) having the smallest density
- B) having the largest density
- C) subject to the greatest atmospheric pressure
- D) having the greatest volume
- E) in which the sphere was submerged the deepest



2) A certain block of wood has a volume of 150 cm^3 and floats on water (density = 1000 kg/m^3) with 25% of its volume submerged. The downward force that must be applied to hold the block completely under water is about:

- A) 0.11 N
- B) 0.37 N
- C) 1.1 N
- D) 1.5 N
- E) $1.1 \times 10^6 \text{ N}$



3) A 8.0 kg solid sphere, made of a metal with a density of 2300 kg/m^3 , hangs suspended by a cord. When the sphere is immersed in a liquid of unknown density, the tension in the cord is reduced to 23 N. The density of the liquid is closest to:

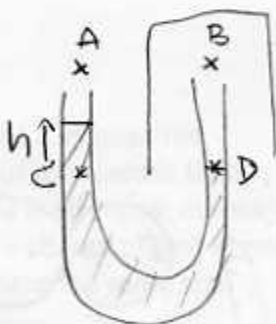
- A) 1600 kg/m^3
- B) 1500 kg/m^3
- C) 1400 kg/m^3
- D) 1300 kg/m^3
- E) 1200 kg/m^3



$V = \frac{m}{\rho_{metal}}$
 $T + pVg - mg = 0$
 $p = \frac{mg - T}{Vg}$
 $= \rho_{metal} \left(1 - \frac{T}{mg}\right)$

4) A U-tube is partially filled with water. One side of the tube is inside of a box with still air and the other side has a wind blowing across the open end with a velocity of 50 km/h. What is the difference in the height of water between the two sides of the tube? Note: $\rho(\text{air}) = 1.2 \text{ kg/m}^3$, $\rho(\text{water}) = 1000 \text{ kg/m}^3$.

- A) 0.016 cm
- B) 0.16 cm
- C) 1.2 cm
- D) 12 cm
- E) 116 cm



$P_A + \frac{1}{2} \rho_{air} v_A^2 = P_B + \frac{1}{2} \rho_{air} v_B^2$
 $P_B - P_A = \frac{1}{2} \rho_{air} v_A^2$ (1)
 Also: $P_C = P_D$
 ie. $P_A + \rho_{water} g h = P_B$
 $P_B - P_A = \rho_{water} g h$ (2)

$\textcircled{1} = \textcircled{2}$ $\frac{1}{2} \rho_{air} v_A^2 = \rho_{water} g h$ $h = \frac{\rho_{air}}{2 \rho_{water}} \frac{v^2}{g}$ ($v = 50 \frac{\text{km}}{\text{h}} = 13.9 \text{ m/s}$)

5) Bernoulli's equation can be derived from the conservation of:

- A) energy
- B) mass
- C) angular momentum
- D) volume
- E) pressure

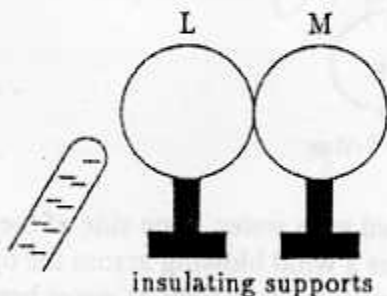
See lecture notes or book

6) Kepler's second law, "A line from the Sun to a given planet sweeps out equal areas in equal times." can be derived from conservation of:

- A) energy
- B) mass
- C) angular momentum
- D) volume
- E) pressure

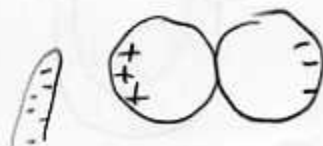
See lecture notes or book

7) Two uncharged metal spheres, L and M, are in contact. A negatively charged plastic rod is brought close to L, but not touching it, as shown below. The two spheres are then slightly separated and, after this separation, the rod is removed. As a result of these steps:



- A) both spheres are neutral
- B) both spheres are positively charged
- C) both spheres are negatively charged
- D) L is negatively and M is positively charged
- E) L is positively and M is negatively charged

The rod polarizes the system.



When the spheres are separated, they have a charge. When the rod is removed, the charges in each sphere are redistributed throughout the sphere.

8) What equal, positive charges would have to be placed on the Earth and the Sun so as to balance their gravitational attraction? (Mass of Sun $\sim 2 \times 10^{30}$ kg)

- A) 9.0×10^9 C
- B) 8.8×10^{12} C
- C) 5.7×10^{13} C
- D) 6.6×10^{15} C
- E) 6.0×10^{17} C

Let's call the charge q :

$$k \frac{q^2}{r^2} = G \frac{M_E M_\odot}{r^2}$$

← distance between Earth and Sun cancels out.

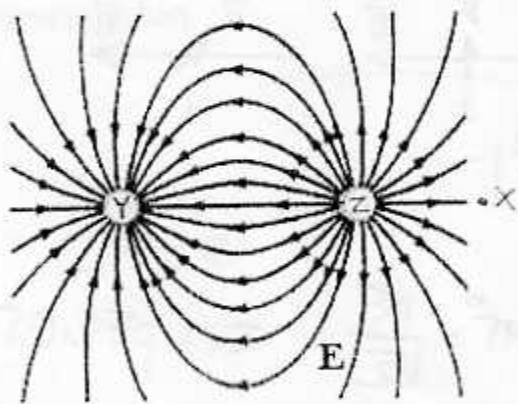
$$q = \sqrt{\frac{G M_E M_\odot}{k}}$$

9) Two particles, X and Y, are 4.0 m apart. X has a charge of $2Q$ and Y has a charge of Q . The ratio of the magnitude of the electrostatic force on X to that on Y is:

- A) 4:1
- B) 2:1
- C) 1:1
- D) 1:2
- E) 1:4

This is Newton's 3rd law!

10) The diagram below shows the electric field lines in a region of space containing two small charged spheres, Y and Z. We can deduce that:



E-lines going into Y
 \Rightarrow Y is negative

E-lines coming out of Z
 \Rightarrow Z is positive

(so A and E are wrong)

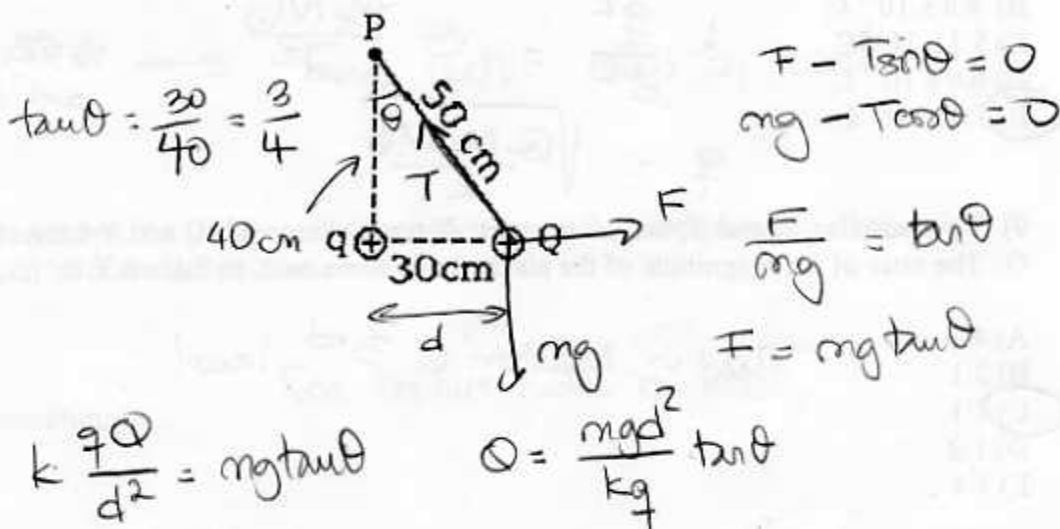
Lines are more densely packed near the charges, so that's where the field is strongest.

(so B and C are wrong)

- A) Y is positive and Z is negative
- B) the magnitude of the electric field is the same everywhere
- C) the electric field is strongest midway between Y and Z
- D) a small negative charge placed at point X would experience a force to the left
- E) Y and Z must have the same sign

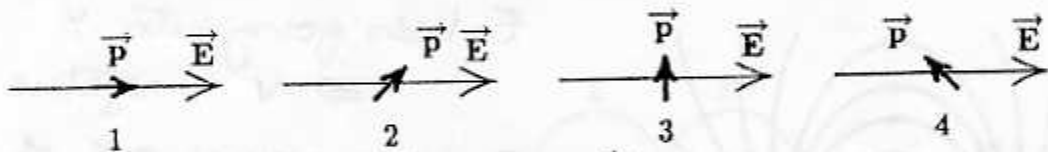
If you place a negative charge at X, the force will point opposite to the E-field, i.e., left

11) In the figure below, a small 80 g sphere is suspended from point P by an insulating thread that is 50 cm long. The sphere bears an unknown charge, Q. A positive point charge, $q = +2.0 \mu\text{C}$, is brought to a position directly below P and the sphere is repelled to a new position, 30 cm to the right of q, as shown. The charge Q is closest to:



- A) $1.5 \mu\text{C}$
- B) $2.0 \mu\text{C}$
- C) $2.5 \mu\text{C}$
- D) $3.0 \mu\text{C}$
- E) $3.5 \mu\text{C}$

12) The diagrams below show four possible orientations of an electric dipole in a uniform electric field (for 2 and 4 the angle with respect to the applied field is 45° and 135°). Rank them according to the magnitude of the torque exerted on the dipole by the field, least to greatest.



- A) 1, 2, 3, 4
- B) 4, 3, 2, 1
- C) 1, 2, 4, 3
- D) 3, 2 and 4 tie, then 1
- E) 1 and 4 tie, then 3

$$|\vec{\tau}| = |\vec{p} \times \vec{E}|$$

$$\tau_1 = pE$$

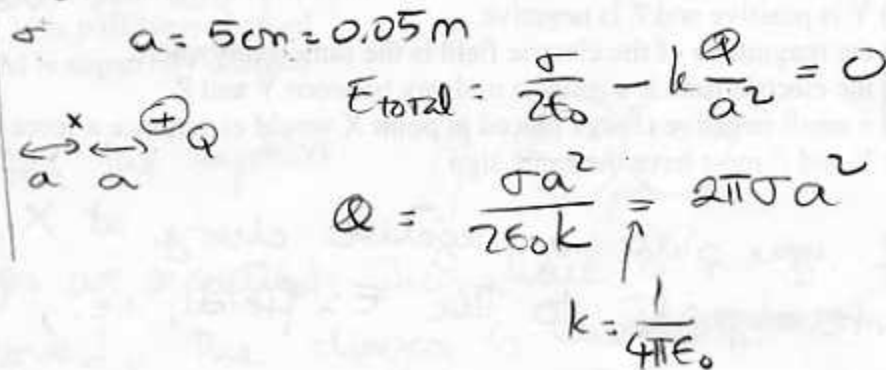
$$\tau_2 = pE \sin 45^\circ = \frac{pE}{\sqrt{2}}$$

$$\tau_3 = 0$$

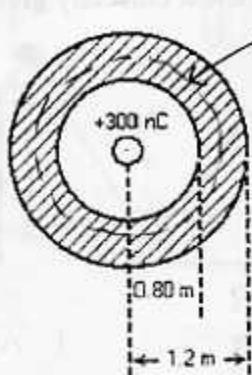
$$\tau_4 = pE \sin 135^\circ = pE \sin 45^\circ$$

13) A point charge, $+Q$ is placed 10 cm from an infinite sheet of charge that has $\sigma = +10 \mu\text{C}/\text{m}^2$. If the magnitude of the electric field is zero half way along the line from the sheet to the point charge, what is the size of Q?

- A) $0.16 \mu\text{C}$
- B) $1.6 \mu\text{C}$
- C) $10 \mu\text{C}$
- D) $16 \mu\text{C}$
- E) $100 \mu\text{C}$



14) A hollow conducting sphere has an inner radius of 0.80 m and an outer radius of 1.20 m. The sphere carries a charge of -500 nC . A point charge of $+300 \text{ nC}$ is present at the center of the sphere. The surface charge density on the outer surface is closest to:



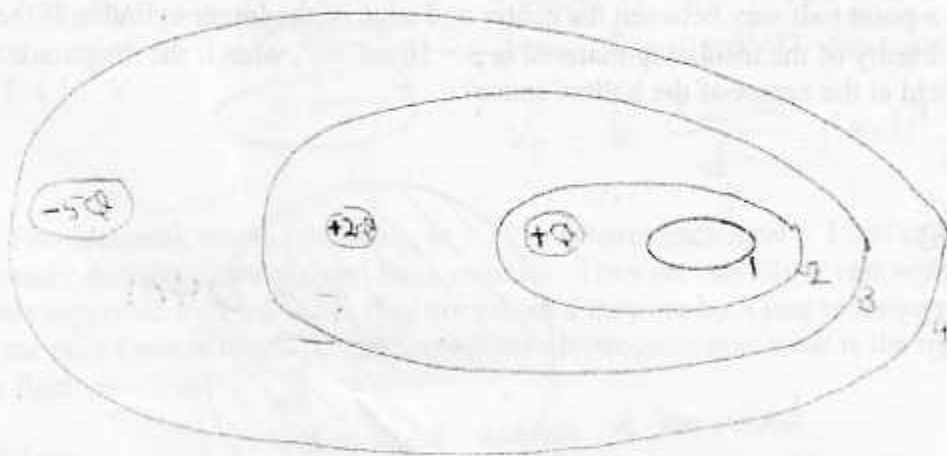
flux = 0
 \Rightarrow enclosed charge = 0
 $= 300 \text{ nC} + Q_{\text{inner}} = 0$
 $Q_{\text{inner}} = -300 \text{ nC}$

- A) 0 nC/m^2
- B) 11 nC/m^2
- C) -16 nC/m^2
- D) -28 nC/m^2
- E) -44 nC/m^2

$Q_{\text{inner}} + Q_{\text{outer}} = -500 \text{ nC} \Rightarrow Q_{\text{outer}} = -200 \text{ nC}$

$\sigma_{\text{outer}} = \frac{Q_{\text{outer}}}{4\pi(1.2\text{m})^2} = -11 \text{ nC/m}^2$

15) The figure below shows four egg-shaped Gaussian surfaces, labeled 1, 2, 3, and 4, enclosing 0, 1, 2, 3 point charges, respectively. The point charges are $+Q$, $+2Q$ and $-5Q$. Rank the surfaces in terms of the magnitude of total flux, $|\Phi_{\text{total}}|$, through each, from lowest to highest.

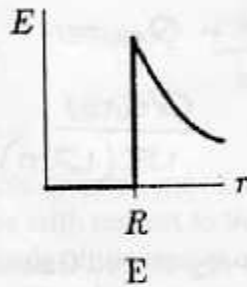
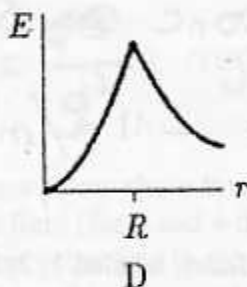
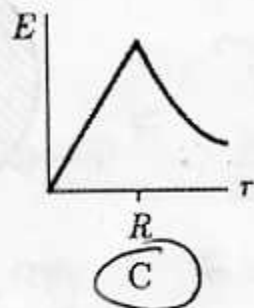
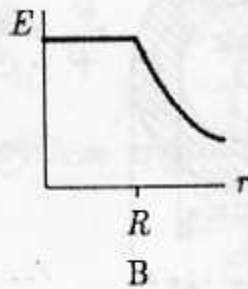
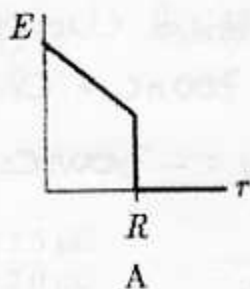


- A) 1, 2, 3, 4
- B) 4, 3, 2, 1
- C) 3, 4, 2, 1
- D) 1 and 4 tie, 2, 3
- E) 1, 2, 4, 3

$\Phi_1 = 0$
 $\Phi_2 = \frac{Q}{\epsilon_0}$

$\Phi_3 = \frac{3Q}{\epsilon_0}$
 $\Phi_4 = \frac{-2Q}{\epsilon_0}$

16) A solid, insulating sphere of radius R contains a uniform volume distribution of positive charge. Which of the graphs below correctly gives the magnitude, E , of the electric field as a function of r ?



Outside, $E \propto \frac{1}{r^2}$
(spherical shell theorem, or using Gauss's law)

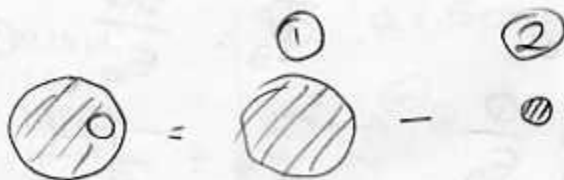
inside: $E 4\pi r^2 = \frac{\rho \frac{4}{3}\pi r^3}{\epsilon_0}$

with $\rho = \frac{Q}{\frac{4}{3}\pi R^3}$

$$E = \frac{1}{4\pi\epsilon_0} \frac{Qr}{R^3}$$

17) A long cylindrical insulator ($r = 0.8$ m) has a cross section as shown. A smaller, cylindrical, hollow space ($r = 0.2$ m) is drilled parallel to the axis of the larger cylinder, but centered on a point half way between the center and edge of the larger cylinder. If the volume charge density of the insulating material is $\rho = 10$ mC/m³, what is the magnitude of the electric field at the center of the hollow space?

- A) 2.3×10^8 N/C
- B) 4.5×10^8 N/C
- C) 6.8×10^8 N/C
- D) 11×10^8 N/C
- E) 18×10^8 N/C



For 1, using Gauss's law: $E_1 2\pi r h = \frac{\rho \pi r^2 h}{\epsilon_0}$ $E_1 = \frac{\rho r}{2\epsilon_0}$

For 2, same thing but $r=0$, so $E_2=0!$
 $\Rightarrow E = E_1 = \frac{(0.01 \frac{C}{m^3})(0.4m)}{2(8.85 \times 10^{-12} \frac{C^2}{Nm^2})}$

