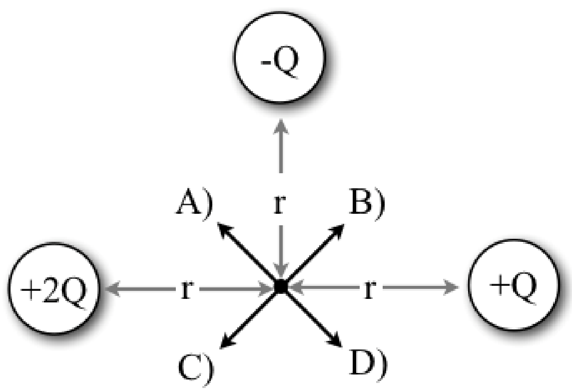
Question 5: Equal amounts of helium gas fill two halves of an isolated container with a thermally conducting partition in the middle. Initially, the temperature is 300K on one side and 400K on the other side. If we observe the gas some time later, we can be sure that the temperatures on the two sides will never be 275K and 425K, because

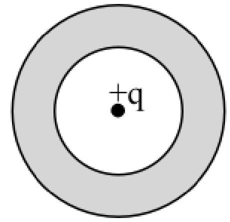
A) this would violate conservation of energy.
B) this would violate the ideal gas law.
C) the partition allows heat to flow from one side to the other, but the temperatures cannot change if the two gases do not mix.
D) this would be extraordinarily unlikely.

Question 6: A point in empty space is equidistant from 3 charges as shown. What is the direction of the electric field at that point?

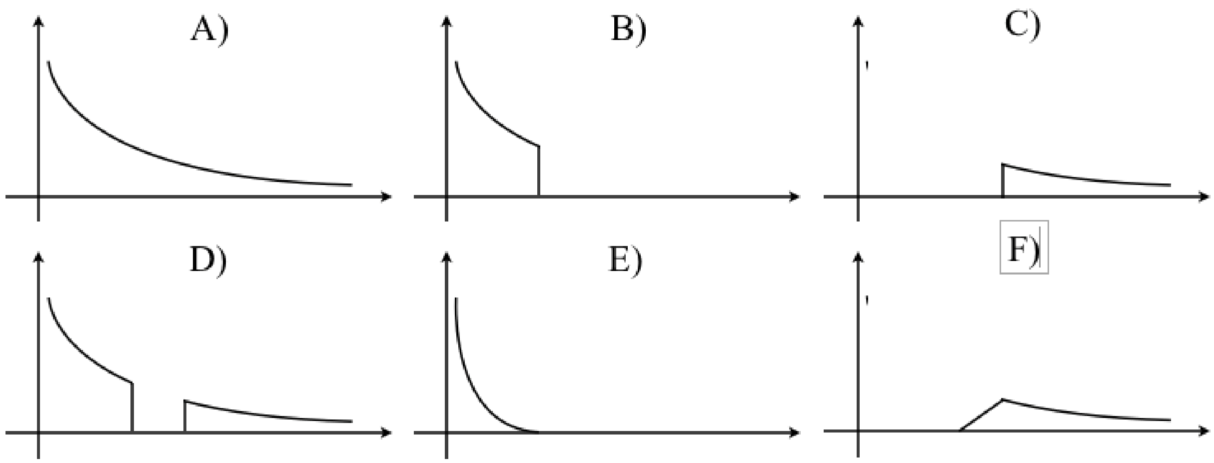


E) None of the angles shown

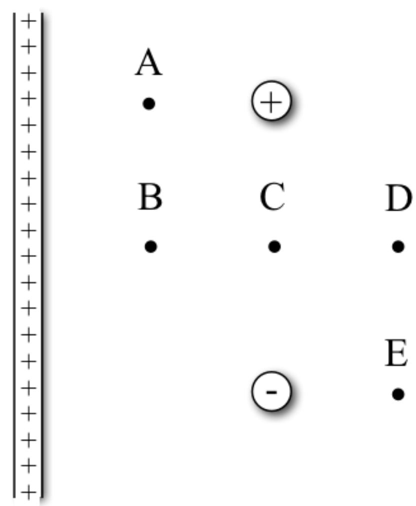
Question 7: A conducting shell has a positive charge sitting inside it, as shown in the figure.



Choose the diagram below that best represents the magnitude of the electric field of this configuration as we move away from the centre.



Question 8: A proton and an electron sit next to a positively charged plate, as shown in the figure. Rank the combined electric potential from the plate and both charges at each point from highest to lowest.

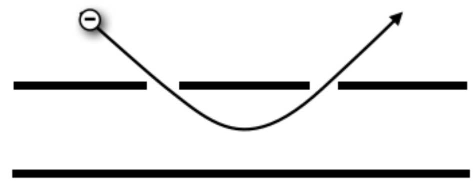


a) A = B = E > C > D
b) D > C > A = B = E
c) A > B = D = E > C
d) C > B = D = E > A
e) A > B > C > D > E
f) E > D > C > B > A

Question 9: Two dipoles are held as illustrated in the figure. Which statement best describes the motion of the dipoles when they are released?

A) They'll both rotate in the same direction and move away from each other.
B) They'll both rotate in the same direction and move towards each other.
C) They'll both rotate in the same direction and stay stationary with respect to each other.
D) They'll rotate in opposite directions and move away from each other.
E) They'll rotate in opposite directions and move towards each other.
F) They'll rotate in opposite directions and stay stationary with respect to each other.

Question 10 (5 points):



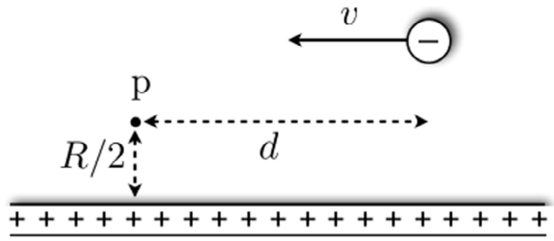
In particle physics experiments it's often useful to make a beam of electrons turn a corner. This can be done using the electric field generated by a parallel plate capacitor.

The figure shows an electron with speed $7 \mathrm{x} 10^6$ m/s enters a hole at a 45° angle, travels 1 cm horizontally, and exits at a 45° angle, completing a 90° turn in the process.

Find the strength and the direction of the electric field that bends this electron.

Question 11 (5 points):

An electron is a distance R away from a wire and travelling at velocity v parallel to the wire. After some time the electron has travelled a distance d forward and is now a $R/2$ away from the wire, labelled p on the figure.



A) Given that the electric field of the wire is $E = k\lambda/r$, where λ is the linear charge density (charge per unit length), what is the potential difference between the initial position of the charge and the point p?

B) What is the kinetic energy of the electron at point p?

FORMULA SHEET

$PV = nRT = Nk_bT$ $R = 8.31$ J/(mol K)

$\Delta E = Q + W$ $\Delta E = n\, C_V\, \Delta T$ $C_V = 3/2R$ (ideal monotomic gas)

$W = -\int PdV$

$PV^{\gamma} = \text{constant}$ $\gamma = 1 + C_V/R$

$T = (2/3k_b)E_{ave}$

$P = (2/3)(N/V)E_{ave}$

$\mathbf{F} = m\mathbf{a}$

$F_r = -dU/dr$ $W = -\Delta U = -\int \mathbf{F}\cdot\mathbf{dr}$

$\mathbf{F} = q\mathbf{E}$ $U = q\, V$

$E_r = -dV/dr$ $\Delta V = -\int \mathbf{E}\cdot\mathbf{dr}$

$E = kq/r^2$ $E = \eta/(2\varepsilon_0)$ $E = 2kp/\, r^3$ $p = qs$

$\text{Flux} = Q_{enc}/\varepsilon_0$

$k = 9 \times 10^9\ \text{N m}^2/\text{C}^2$ $\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2/(\text{N m}^2)$