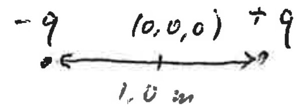
PHYS 1120 Discussion 3

Barrans preliminary answers

1. Point charges



a. Charge q if field at the origin is 1 N/C

Field is directed to the left, in the -x direction

It is a superposition of fields from the two charges

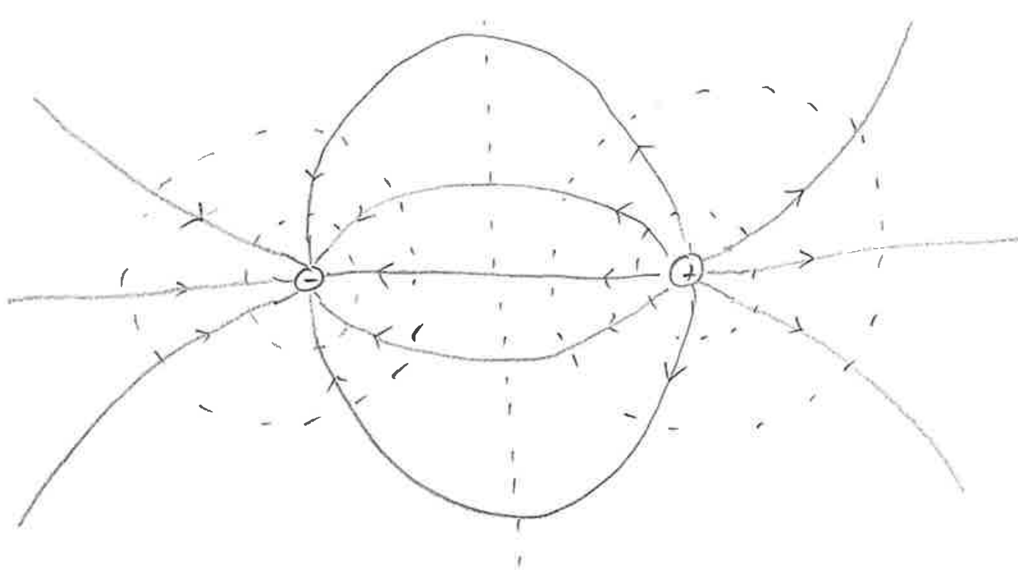
Both of these two fields point in -x direction at the origin, both have distance r = 0.50 m and same charge magnitude q

$$E = \frac{kq}{r^2} + \frac{kq}{r^2} = \frac{2kq}{r^2}$$

$$q = \frac{Er^2}{2k} = \frac{(1\ N/C)(0.5m)^2}{2\cdot 8.99\times10^9\ \frac{Nm^2}{C^2}} = 1.39\times10^{-11}\ \frac{N\,m^2C^2}{C\,N\,m^2}$$

$$\boxed{q = 1.39\times10^{-11}C}$$

b.



Solid lines are field lines, dashed lines are isopotentials

c. Electric potential at the origin

Direction to the source charge does not affect potential; only distance does. The origin is $r_+ = 0.5$ m from the positive charge, and $r_- = 0.5$ m from the negative charge.

$$V = \frac{k(-q)}{r_-} + \frac{k(+q)}{r_+} = \boxed{0}$$

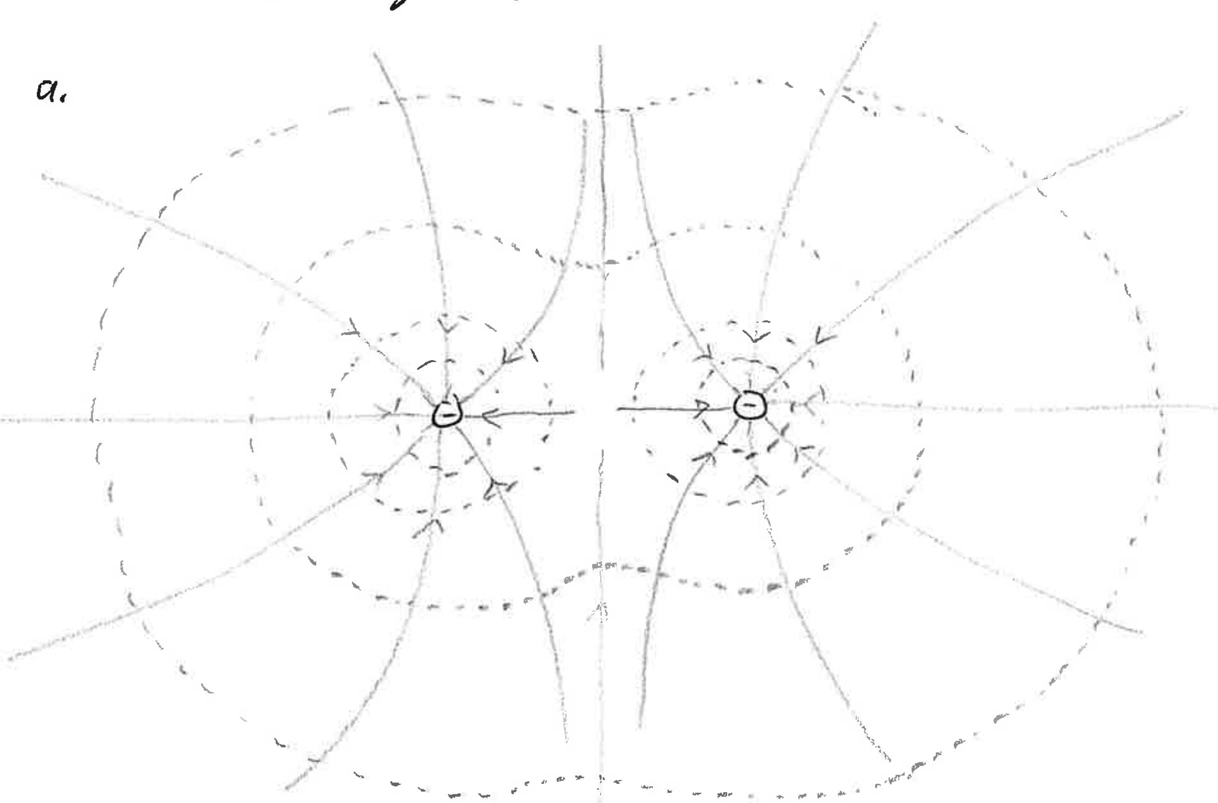
d. Rank electric potential

Electric potential is higher near the positive charge. It takes positive work to move a positive test charge from far away to a positive charge, but it takes negative work to move a positive test charge from far away to a negative charge.

e. On diagram. Isopotential surfaces are perpendicular to field lines.

2. Both charges negative

a.



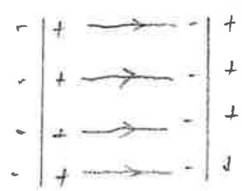
b The potential is negative at the origin; the origin is a saddle point between the two minima at the source charges themselves.

$$V = \frac{kq_1}{r_1} + \frac{kq_2}{r_2} = \frac{k(-q)}{r} + \frac{k(-q)}{r} = -2kq/r$$

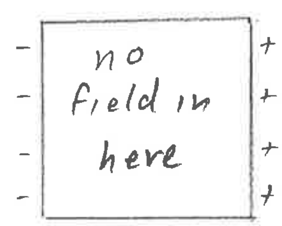
$$= -2 \cdot 8.99\times10^9 \frac{Nm^2}{C^2} \cdot 1.39\times10^{-11} C / 0.5 m$$

$$= -0.500 \ Nm/C = \boxed{-0.500 \ V}$$

3. a Both plates will have − charge on the left and + charge on the right. The field between the plates will be the same as the field outside.



b If the plates are connected by conductors, charge will polarize across the box.



4 a Outside the sphere

A spherical Gaussian surface of radius $r > R$ has area $4\pi r^2$ and flux $-Q/\varepsilon_0 = E \, 4\pi r^2$, thus

$$E = \frac{1}{4\pi\varepsilon_0} \frac{-Q}{r^2}$$ outside the sphere

b $E = 0$ inside the sphere, because $E = 0$ inside a conductor.

c Inside the sphere, any Gaussian surface encloses zero charge, so the field has no sources nor sinks (zero divergence, if you're into vector calculus). The only way such a field could have spherical symmetry is if the field is everywhere zero.

d. i. Potential inside the sphere is negative because it would take negative work to move a positive test charge there.

ii Potential inside equals the potential at the surface because the field, which is the chang in potential, is zero.

e Outside the sphere, the field and potential are the same as what would arise from a point charge. Inside the sphere, field is zero and potential is level.