University Physics 2 – Spring 2012 – Test 3 – 03/23/12 SOLUTION KEY

Choose 5 out of 6 problems (24 points each)

$$nC = 10^{-9} C \quad k = 9x10^9 \frac{Nm^2}{C^2} \quad \varepsilon_0 = 8.85x10^{-12} \frac{C^2}{Nm^2} \quad EA = \Phi = \frac{q_{enc}}{\varepsilon_0} = 4\pi k q_{enc} \quad 400nm \le visible \le 700nm$$

1) If you missed the "walking tacos" on Tuesday night, then you missed the greasy layer of oil that was on the glass surface of the crock pot. The index of refraction for each layer is shown to the right. The thickness of the oil film is **900 nm**.

air n=1.0
Oil n=1.2
Glass n=1.5

a) If white light shines down from the top, nearly vertically, which wavelengths of **visible** light will **NOT** reflect back (dark) and which would reflect brightly (bright)?

b) If you took the glass away (so it was air-oil-air) how would that change your answers to part A?

c) What if the film index value increased slightly (maybe as it dried) – how would that change your wavelength answers? Don't calculate – just explain relatively what would happen to the wavelength values.

d) In the original situation (air/oil/glass), suppose you only used a single wavelength of light (**λ=490 nm**).. describe **qualitatively** the kind of reflection you might see from that wavelength of light. (You don't have to calculate anything.)

a) $m^*_{low} = \frac{2tn_{film}}{700} = \frac{2(900)(1.2)}{700} = 3.08 \quad m^*_{high} = \frac{2160}{400} = 5.4 \quad m_{int} = 4, 5 \quad m_{half\_int} = 3.5, 4.5$

For light-heavy-heaviest .. integers = bright, **half-integers = dark** :

$BRIGHT : \lambda_4 = \frac{2160}{4} = 540nm, \lambda_5 = 432nm$ $\quad$ $DARK : \lambda_{3.5} = \frac{2160}{3.5} = 617nm, \lambda_{4.5} = 480nm$

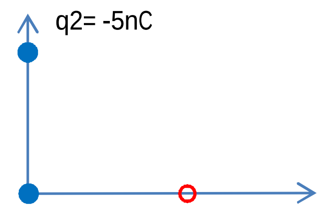
b) now we have introduced an extra phase reflection – so the brights switch to darks and the darks switch to brights.

c) since the film index is now bigger, then the 2tn(film) value will get bigger, and wavelengths will get slightly bigger.

d) the 490 is pretty close to the 480 .. 480 was dark, so there shouldn't be very much of the 490 reflecting back, but a little.

2) Two point charges are on the y axis as shown, with a point P on the x axis. Charge **q1 = +5nC** is at the origin, charge **q2= -5nC** is at (0, 0.2m) and point P is at (0.2m, 0) as shown.

a) What is the net electric field at point P (magnitude and direction)?



[*Treat the above situation as the reference situation for the following questions. In answering, would the magnitude of E* ***increase, decrease, or stay the same*** *.. also, would the E field direction rotate* ***CW, CCW, not change, or flip 180 degrees****? Each situation returns to the original case and then makes a change.*]

b) What happens to the magnitude and direction of the E field at P if you **increase the magnitude of q1**?

c) What happens to the magnitude and direction of the E field at P if you **move point P further to the right on the x axis**?

d) What happens to the magnitude and direction of the E field at P if you **reverse the sign of q2**?

e) What happens to the magnitude and direction of the E field at P if you **reverse the sign of both charges**?

a) $E_1 = \frac{9x10^9(5x10^{-9})}{0.2^2} = 1125N/C \quad E_2 = \frac{9x10^9(5x10^{-9})}{(0.2\sqrt{2})^2} = 562.5N/C \quad E_{2X} = 562.5\cos(45) = 397.75 = E_{2Y}$

$E_x = +1125 - 397.75 = +727.25N/C \quad E_y = 0 + 397.75 = +397.75N/C \quad E = 828.92N/C \; at \; 28.7 \deg \text{ North of East}$

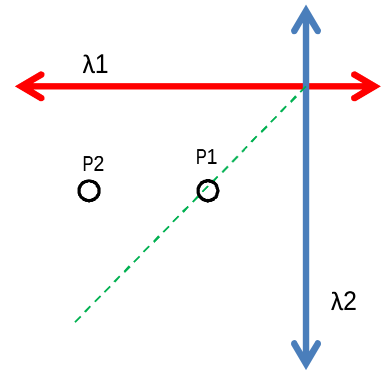
b) since E1 increases – will increase the magnitude of E .. and rotate the vector CW

c) since E1 decreases – will decrease the magnitude – rotate the vector CCW

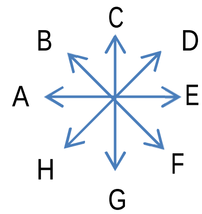
d) E2 switches direction – this will make it point SE – thus making a larger vector – and rotating CW

e) switch both vector directions … so magnitude = SAME and direction = 180 degree flip

3) Two infinite lines of charge are oriented as shown. Initially **λ1= λ2=+2nC/m**. Consider the net electric field directions at points P1 and P2.



Consider the following possible vector directions:
If a vector pointed NW, you would indicate B,if a vector pointed somewhere East of North, but not NE, you could indicate CD as the vector direction, etc.



a) What are the directions of the net electric fields at point P1 and at point P2 for this given situation?

Direction code letters at P1 = _ H _ Direction code letters at P2 = __ GH ___

Consider the above as the reference situation – always return to that before you make the individual changes below:

b) Suppose the **λ2 switched sign**: Direction at P1 = __F___ Direction at P2 = __ FG _

c) Suppose the **λ2 doubled in magnitude**: Direction at P1 = _ AH _ Direction at P2 = __ H _

d) Suppose **both λ1 and λ2 switched their signs**: Direction at P1 = _ D __ Direction at P2 = __ CD _

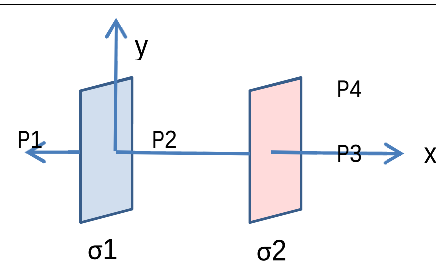
e) in the original configuration, what is the calculated **magnitude** of the net electric field (in N/C) at point P1 (assume P1 is **0.2 meters** from each wire)?

a) P1: E1=E2 and are perpendicular – both point away from wire, thus SW – thus P1: H
P2: E2<E1 and perpendicular – more south than west .. thus P2: GH
b) Horizontal components switch direction
c) Horizontal components now equal vertical at P2 but E2>E1 at p1
d) switch both components of both – so 180 degrees from a)

a) P1: H	P2: GH
b) P1: F	P2: FG
c) P1: AH	P2: H
d) P1: D	P2: CD

e) $E_1 = E_2 = \frac{2k\lambda}{r} = \frac{2(9x10^9)(2x10^{-9})}{0.2} = 180N/C \quad E_{net} = 180\sqrt{2} = 254.6N/C$

4) Two infinite sheets of charge are parallel to each other and perpendicular to the x axis. One is located at the origin (**σ1 = +(4/π) nC/m^2**) and the other is located at x=2m (**σ2 = -(5/π) nC/m^2**). *(The weird "divide by pi" in the charge densities is just to make the numbers come out nicely!)*



a) What is the net electric field (mag/direction) at a point P1 located at (x= -2m, y=0)?

b) What is the net electric field (mag/dir) at a point P2 located at (x=+0.5m, y=0)?

$$E_{plane} = 2\pi k\sigma = \frac{\sigma}{2\varepsilon_0}$$

c) What is the net electric field (mag/dir) at a point P3 located at (x=+2.5m, y=0)?

d) What is the net electric field (mag/dir) at a point P4 located at (x=+2.5m, **y=+2.5m**)?

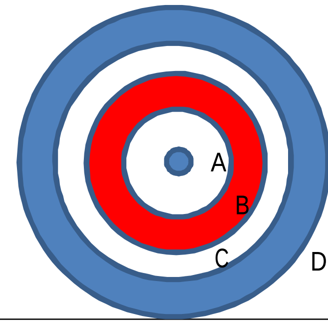
$|E_1| = 2\pi k\sigma_1 = 18\pi(4/\pi) = 72N/C \quad |E_2| = 2\pi k\sigma_2 = 18\pi(5/\pi) = 90N/C$

a) E=-72+90**=+18 N/C (East)** b) +72+90= +162 (thus **162 N/C East**) c) +72-90 = -18 (thus **18N/C West**) d) **same as c**)!

5) A point charge of **+4 nC** is located at the origin. A concentric conducting shell has an inner radius of Ra and outer radius of Rb – and has a net charge of **-6 nC**. A second concentric conducting shell has an inner radius of Rc and outer radius of Rd and a net charge of **+5 nC**.

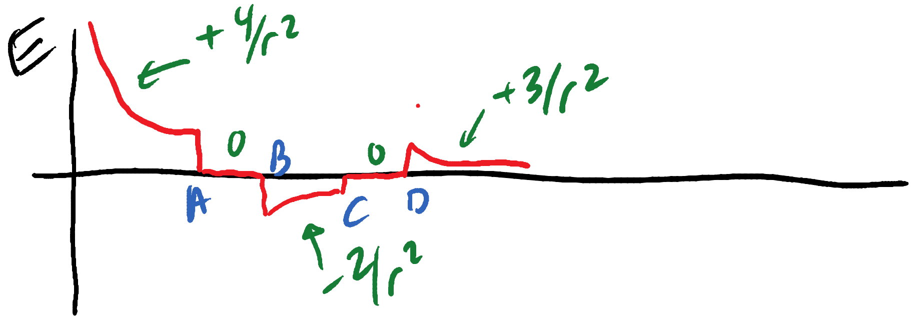
a) What is the magnitude and signs of the charges at Ra, Rb, Rc, Rd? And explain your reasoning for those answers!

b) Sketch the electric field as a function of radius out from the origin.

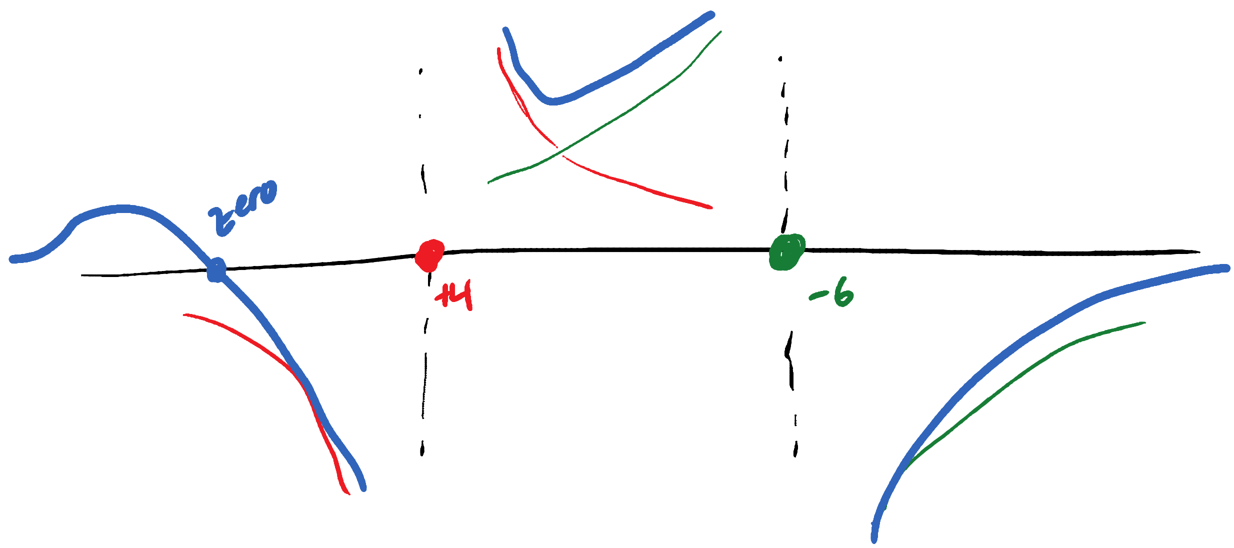


a) Qa = -4 nC (opposite center point charge) Qb = -2 nC (Qa + Qb = net of -6 nC .. and Qb = net charge up to that point = +4-6 = -2 Qc = +2 nC (opposite Qb) Qd = +3 nC (Qc+Qd = net of +5 and Qd = net charge up to that point

QA = -4
QB = -2
QC = +2
QD = +3



6) Two point charges are on the x axis. Charge Q1 = **+4 nC** is at the origin. Charge Q2 = **-6 nC** and is at a distance of **0.5 meters** along the +x axis. Sketch the net electric field (the Ex component) along the x axis from this collection of charges (with the convention that +E means it points to the right and –E points to the left). Also, calculate the location of one point on the axis where the net electric field is zero due to those two charges.



a) $\frac{4}{x^2} = \frac{6}{(x+0.5)^2} \quad \frac{x+0.5}{x} = \sqrt{1.5} \quad x+0.5 = x\sqrt{1.5} \quad x = \frac{0.5}{\sqrt{1.5}-1} = 2.22m$ to left of Q1

Choose 5 out of 6 problems

University Physics 2 – Spring 2012 Test 3 – 03/23/12   Name ____

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Honor Code Pledge: "I have neither given nor received unauthorized aid in completing this work, nor have I presented someone else's work as my own."

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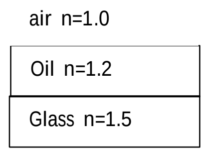

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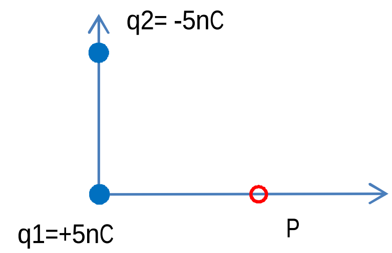

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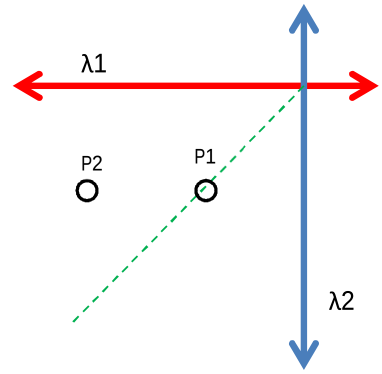

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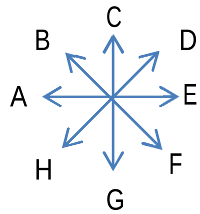

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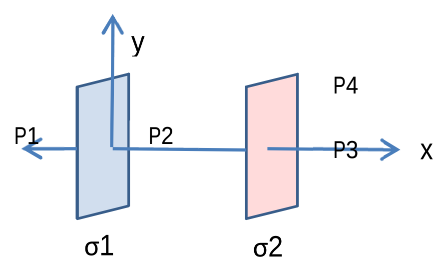

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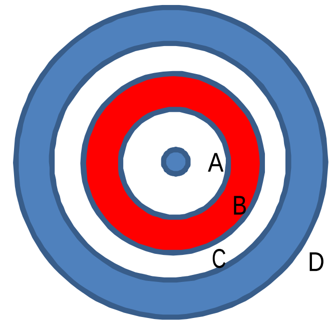

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