Lecture 13: 02/27/2024

- Announcements
  HW Written 4 is up
  - Tutorials in recitation
  - More about potential
  - Will publish solutions and rubric for exam

  "Lecture 11" does not exist (it was the test)
  I made the ones go away from Canvas …
  Will publish solutions to exam

- Today
  Exam review

Aussie Grading Scheme:

Numerical Ave.	Grade
90-100	A
80-90	A-
77-79	B+
73-76	B
70-72	B-
67-69	C+
63-66	C
60-62	C-
55-59	D+
51-54	D
<=50	F

Class Stats:

Top Grade 100
Average/Median Grade 68 C+

15 A's
7 B's
11 C's
4 D's
11 F's

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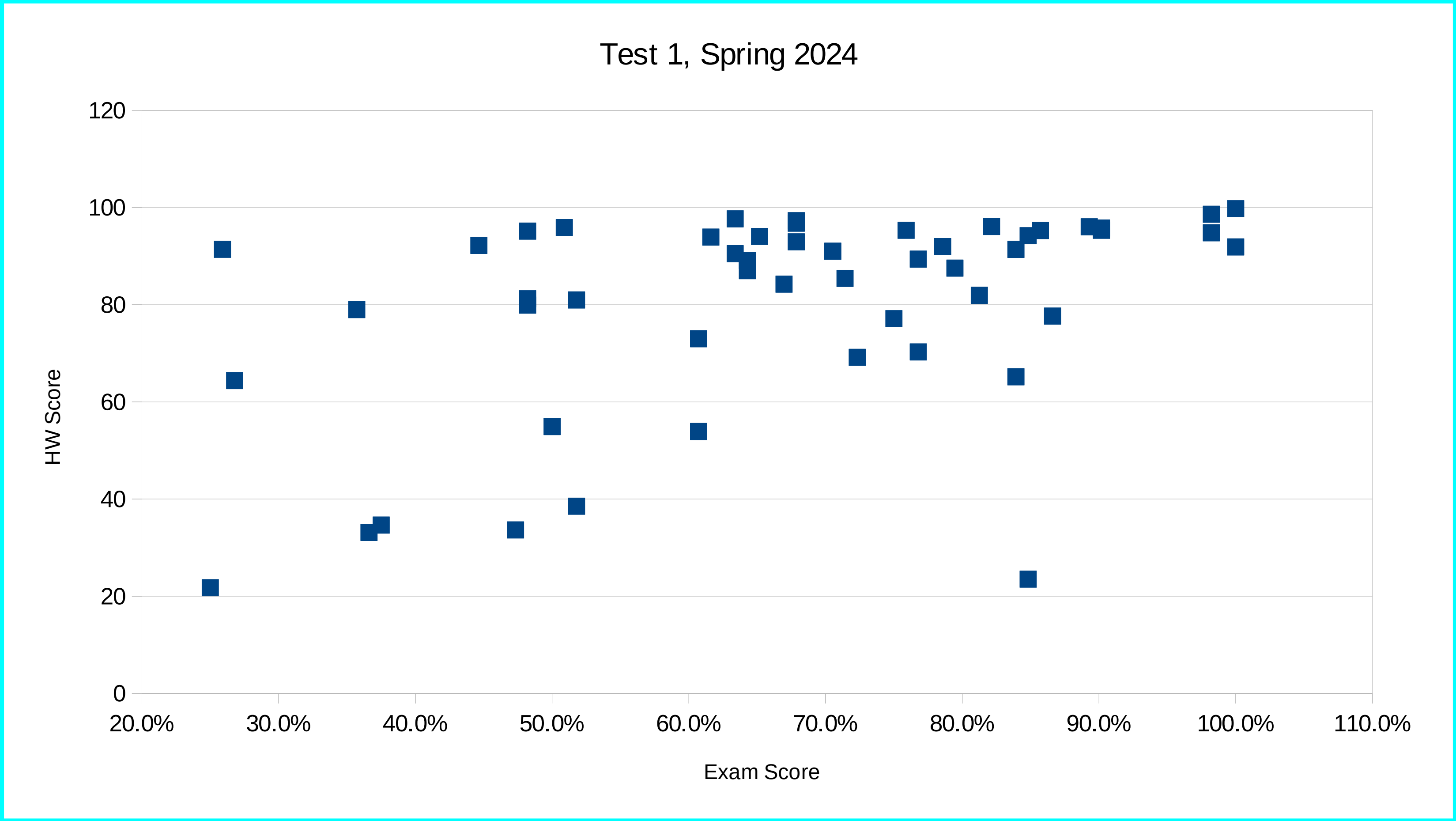
Top Grade 100
Average/Median Grade 68 C+



1. Figure 1 shows an equilateral triangle with charges at its vertices. What is the direction of the net force on the $-2q$ charge at the top?

   A. Along the left side of the triangle

   B. Along the right side of the triangle

   C. Up

   D. Down

   E. to the right

2. I rub plastic with rabbit's fur and the fur ends up with a charge of +3.2 picoCoulomb. This means that ______________electrons were removed from the rabbit's fur.

3. The SI units of electric flux are ______________.

4. A thin wire is 2 meters long and has a charge of 8 nC. The electric field 5 cm from the center of the wire is? A. 1.21×10^{-8} N/C B. 90 N/C C. 1440 N/C D. 28,800 N/C E. 28,800 N

5. Below are four sketches of three charges $q_1 = 1\ \mu C$, $q_2 = 2\ \mu C$, $q_3 = -2\ \mu C$.

   (a) On sketch (a), draw the Gaussian surface that will have the largest total flux

   (b) On (b), draw a Gaussian surface that will have a negative total flux

   (c) On (c), draw a Gaussian surface that will have a zero total flux

   (d) On (d), draw a DIFFERENT Gaussian surface that will have zero total flux

(a) (b) (c) (d)

$$N = \frac{Q}{e} = \frac{3.2\times10^{-12}\,C}{1.6\times10^{-19}\,C} = 2\times10^{7}$$

20000000

$$\lambda = \frac{Q}{L} = \frac{8\times10^{-9}}{2}$$

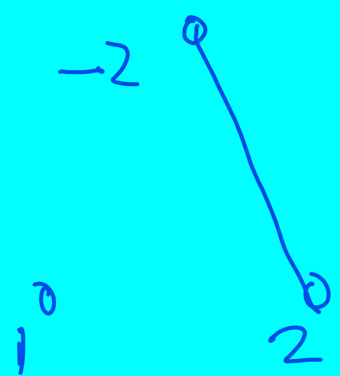
← 2m →

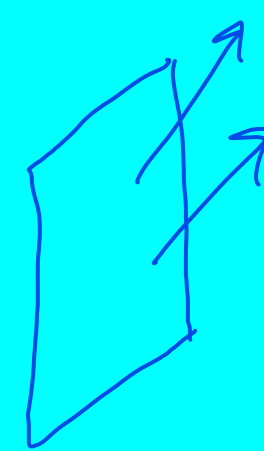
$Q = 8nC$

$$E = \frac{\lambda}{2\pi\epsilon_0 r} = \frac{4\times10^{-9}}{(2\pi)(\epsilon_0)(.05)} = 1440\,V/m$$

$$\Phi = \frac{q}{\epsilon_0} \qquad \int \vec{E}\cdot d\vec{x} = \frac{q}{\epsilon_0}$$

$$\Phi = \vec{E}\cdot\vec{A}$$





________________electrons were removed from the rabbit's fur.

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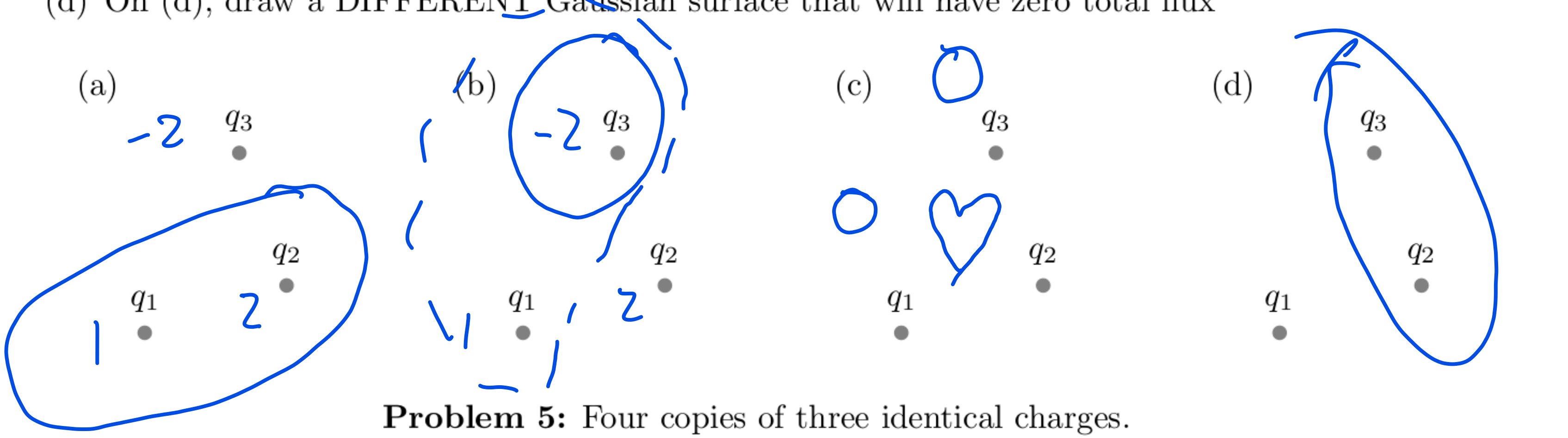
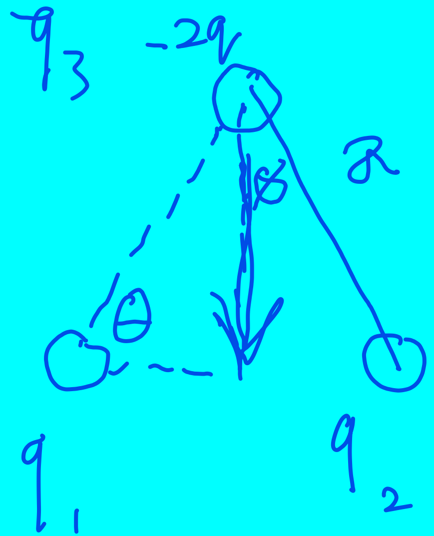


Problem 5: Four copies of three identical charges.



$q = 4\,\mu C$ $\quad 4 \times 10^{-6}\,C \quad 2q = -8 \times 10^{-6}$

$a = 15\,cm = .15$

$\vec{E}_3 = \vec{E}_1 + \vec{E}_2 = \dfrac{kq_1}{a^2} + \dfrac{kq_2}{a^2}$

4, 5

$E_{1y} = E_1(-\sin\theta)$

$E_1 = \dfrac{kq}{a^2} = (9 \times 10^9)\dfrac{(4 \times 10^{-6})}{(.15)^2} = \dfrac{36 \times 10^3}{2.25 \times 10^{-2}}$

SOH-CAH-TOA

$-2q \quad (8 \times 10^{-6})$

$E_{1y} + E_{2y} = k\dfrac{36 \times 10^3}{2.25 \times 10^{-2}}\dfrac{\sqrt{3}}{2}(2) = -22.14\,N\,\hat{j}$

F

$F = Q\vec{E}$

this equation with appropriate numbers: $y(x, t) = A\cos(kx - \omega t)$

(b) Do you have enough information to calculate the mass per unit length of the string?

(c) Do this if you can.

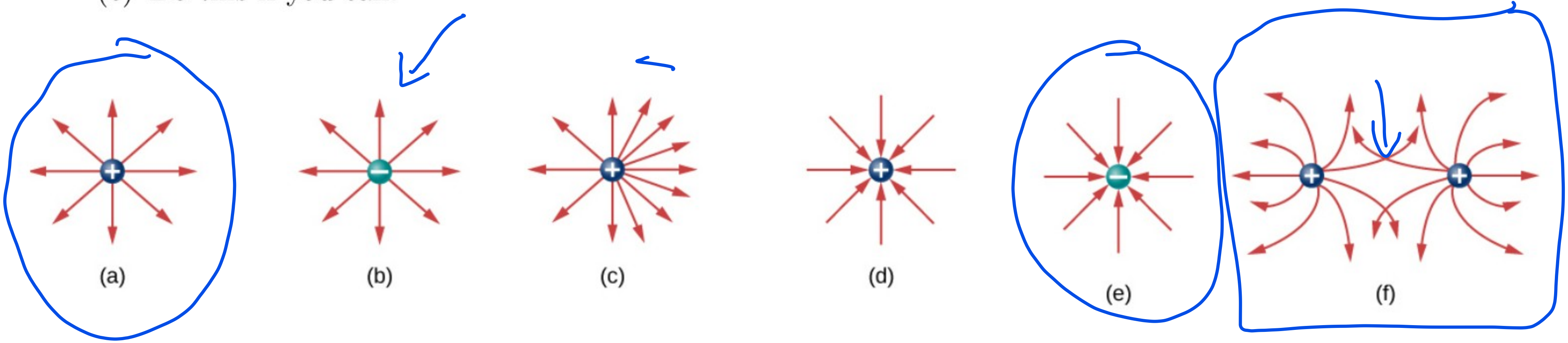


Fig. 2: Which of these fieldline sketches are incorrect?

Constant	Value (SI units)
fundamental charge	$e = 1.60 \times 10^{-19}$
electron mass	$m_e = 9.11 \times 10^{-31}$
proton mass	$m_p = 1.67 \times 10^{-27}$
Coulomb constant	$k = \frac{1}{4\pi\epsilon_0} = 8.99 \times 10^{9}$
Planck's constant	$h = 6.626 \times 10^{-34}$
Boltzmann's constant	$k_B = 1.381 \times 10^{-23}$

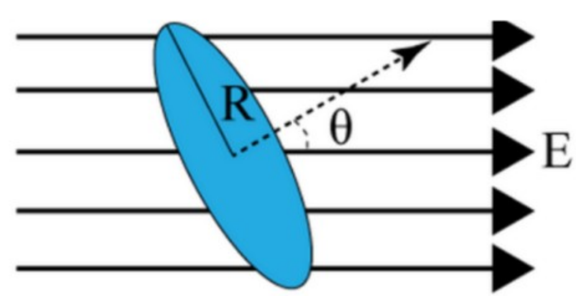


Fig. 3: Find flux through circle

6. In Figure 2, the sketches labeled ________________ are possible CORRECT sketches of fieldlines.

Part 2: Long answer
(Show all work on a separate page. Be mindful of units! Please provide answers in SI units.)

7. Refer again to Figure 2. For each sketch that you did NOT pick in problem 4, briefly explain what is wrong with the sketch.

8. Referring back Figure 1 at the top of the exam. Let q = 4 nC, -2q = -8 nC and a = 30 cm. Determine the net force on the -2q charge.

9. In Figure 3, $\theta = 27^o$.

   (a) What quantities besides θ would you need in order to calculate the electric flux through the circle?

   (b) Make up numbers (free choice!) for each of the quantities from part "a" and use them to calculate the total flux.

10. A rectangular sheet of charge is 0.5 cm wide by 10 cm long and has a uniform charge density of $\sigma = -7\ nanoCoulombs/m^2$.

   (a) Draw this rectangle on your paper and put a dot labeled 'P' in the middle of your sketch. (Yes ... points for drawing ... it does not need to be pretty!)

   (b) Imagine a one μC positive charge floating 1 mm above the point 'P'. Estimate the magnitude and direction of the force on this charge.

   (c) The same charge is moved 100 m from your paper. Estimate the magnitude of the force now.

$$\vec{E} = k \frac{q_1}{r^2} \hat{r}$$

$$\vec{E} = \frac{\sigma}{2\epsilon_0} \hat{n}$$

$$\vec{F} = q \frac{\sigma}{2\epsilon}$$

$$\vec{F} = Q\vec{E}$$

$$\vec{E} = \frac{\lambda}{2\pi\epsilon_0 r} \hat{r}$$

$$3.5\ nC = Q$$

$$\lambda = \frac{Q}{L} = \frac{3.5\times10^{-9}}{.1}$$

$$\lambda = 3.5\times10^{-8}\ C/m$$

$$E = \frac{\lambda}{2\pi\epsilon_0 r} = \frac{3.5\times10^{-8}}{(2\pi)(\epsilon_0)(10^{-2})}$$

$$= 6.3\times10^{4}$$

$$F = qE = .5\ N$$

(b) Make up numbers (free choice.) for each of the quantities from part 'a' and use them to calculate the total flux.

10. A rectangular sheet of charge is 0.5 cm wide by 10 cm long and has a uniform charge density of $\sigma = -7\ nanoCoulombs/m^2$.

(a) Draw this rectangle on your paper and put a dot labeled 'P' in the middle of your sketch. (Yes ... points for drawing ... it does not need to be pretty!)

(b) Imagine a one μC positive charge floating 1 mm above the point 'P'. Estimate the magnitude and direction of the force on this charge.

(c) The same charge is moved 100 m from your paper. Estimate the magnitude of the force now.

(d) The same charge is brought back to 1 cm from your paper. Explain how you would estimate the magnitude of the force now and then calculate it.

11. A guitar string is under a tension of 80 N. When you pluck it it makes a musical sound with a frequency of 440 Hz. You cannot remember how standing waves work but your kindly professor tells you that the wavelength of this note is 1.5 meters.

(a) $y(x,t)$ is the deflection (position) of this guitar string. As best as you can, replace the constants in this equation with appropriate numbers. $y(x,t) = A\cos(kx - \omega t)$

(b) Do you have enough information to calculate the mass per unit length of the string?

(c) Do this if you can.

$v = f\lambda$ $\quad A$ $\quad \omega = (2\pi)(440) = 2764$

$k = \frac{2\pi}{\lambda}$ $\quad y = \underline{A} \sin(kx - \omega t)$ $\quad v = \sqrt{\frac{T}{\mu}}$

$\omega = 2\pi f$ $\quad k = \frac{2\pi}{\lambda} = \frac{2\pi}{1.5} = 4.2$ $\quad v^2 = \frac{T}{\mu}$

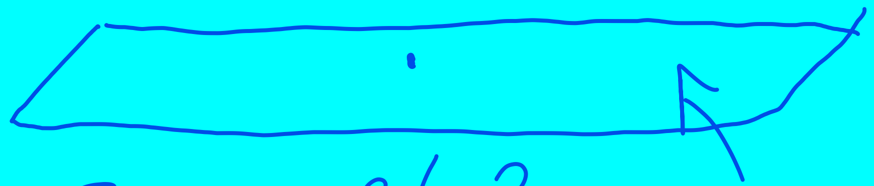
$y = A \sin(4.19x - 2764t)$ $\quad \mu = \frac{T}{v^2}$

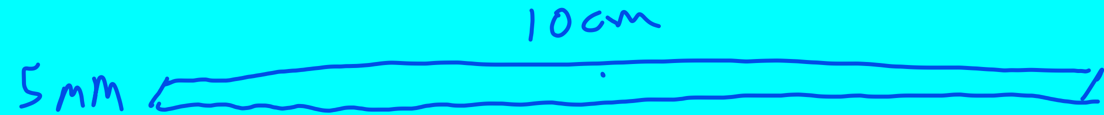
$\mu = \frac{80N}{}$ $\quad \omega = \frac{2\pi}{T}$

$v = f\lambda = (440)(1.5)$ $\quad \mu = \frac{80N}{(660)^2}$

$v = \omega / k$ $= 660 \text{ m/s}$

$T \quad T$ $\quad 1.84 \times 10^{-4}$ kg/m





$\bullet\ P = 1\,\mu C$

$\sigma = 7\,nC/m^2$ $\quad Q = \sigma A = (7\times10^{9})(5\times10^{-3})(.1\,m) = 3.5\,nC$

$$E = \frac{\sigma}{2\varepsilon_0} =$$

a) $$F = q\frac{\sigma}{2\varepsilon_0} = (10^{-6})\frac{7\times10^{-9}}{(2)(8.85\times10^{-12})}$$

$$= -3.16\,N$$

b) $$F = \frac{k q_1 q_2}{r^2} = \frac{k(10^{-6})(3.5\times10^{-9})}{(10^{2})^2} = \frac{(9\times10^{9})(10^{-6})(3.5\times10^{-9})}{10^4}$$

$$= 2.5\times10^{-8}\,N$$