Physics 122A
Autumn 2018

122A-TOLICH

Exam 1
Oct. 18, 2018

Printed Name Hallinan Skyler **Seat Number** G5
last *first*

I certify that the work I shall submit is my own creation, not copied from any source, and that I shall abide by the examination procedures outlined below.

Signature ____________ **Student ID Number** 1732227

READ THIS ENTIRE PAGE NOW, BEFORE THE HALF-HOUR BELL.
Do not open the exam before the half-hour bell.
You will have 60 minutes after the bell to complete the examination.
Exam papers will no longer be accepted after 61 minutes have elapsed.
NO CELL PHONES, TEXT MSG, etc. ALLOWED AT ANY TIME

Before the exam begins:

- Print and sign your name, and write your student ID number and the number of your seat in the spaces on this page (above).
- Write your name and student ID number on your bubble sheet, and fill in the corresponding "bubbles" using **dark** pencil marks.

During the exam:

- **Important first step:** Print your name and student ID at the top of **each** page.
- If you are confused about a question, raise your hand and ask for an explanation.
- If you cannot do one part of a problem, move on to the next part.
- This is a closed book examination. You have access to the equation sheet included with this exam and to things written on the classroom board by the instructor.
- You may use a calculator, but you **may not use** text storage capabilities, graphics capabilities, internet connections, phones, nor any programmable device.
- You may not use scratch paper, you may not communicate with any person.

For multiple-choice problems (those on white paper):

- Fill in bubble sheets carefully and **darkly**. Make no stray marks. Erase carefully.
- Also circle your choices directly on the exam paper for later reference.

For hand graded problems (those on colored paper):

- If you need more space than is available to answer any part of a problem, use the **back side of the same page** to complete your answer. Clearly indicate to the grader that you used the back side. Do not use scratch paper.
- Show your work in enough detail so that the grader can follow your reasoning and your method of solution. Circle your answers, and state units if appropriate. For numerical answers significant figures should match the number of significant figures in the numerical values given in the problem (usually 2 or 3).

Name Hallinan Skyler Student ID 1732227 Score

last *first*

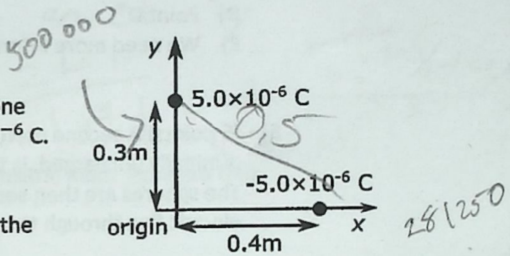
I) Lecture multiple choice (40 points total)

1) (5 points) In the lecture demos and labs, a charged object would often be "grounded" by touching it with a grounding object. What properties must the grounding object have?

   A) It must be a conductor. Must be a conductor
   B) ~~It must be an insulator.~~
   C) It must be large relative to the charged object. Must
   D) A and C
   E) ~~B and C~~

Use the following situation for the next two problems.

As shown, two particles are placed in an xy coordinate system where one particle has charge $+5.0 \times 10^{-6}$ C and the other has charge -5.0×10^{-6} C.

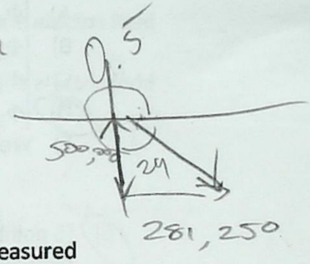


2) (5 points) What is the magnitude of the electric force between the two charges?

   A) 0.18 N
   B) 0.46 N
   C) 0.90 N
   D) 2.9 N
   E) 5.7 N

D = 0.5 m

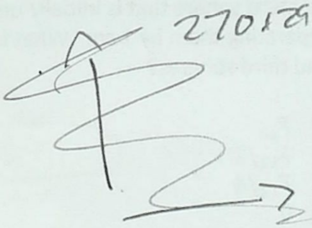
= 0.9

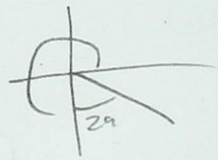


3) (5 points) What is the direction of the electric field at the origin? The angle is measured counterclockwise from the positive x axis.

   A) 29°
   B) 61°
   C) 241°
   D) 299°
   E) 331°

270 + 29 = 299



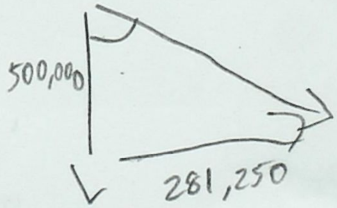


$k \, q_1$

9×10^9

281250 right

500,000 down



$\emptyset = 29.$

$\tan^{-1}\left(\frac{281,250}{500,000}\right)$

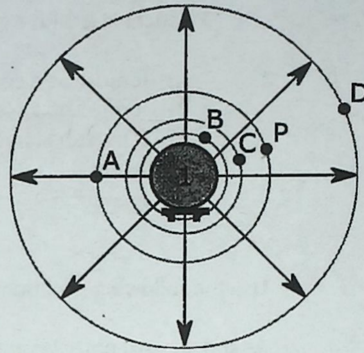
Name Hallinan Skylar Student ID 1732227 Score________

last *first*

Use the following situation for the next three problems.

You place an excess of **positive** charge on a small metal sphere that is attached to an insulating stand.

4) (5 points) The diagram shows the metal sphere with the resulting electric field lines and equipotential lines. If we start off at point P, moving to which point will result in the largest increase in electric potential?

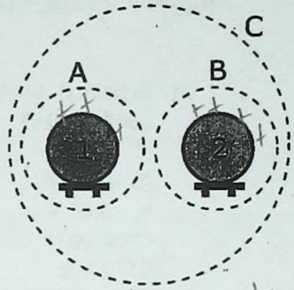


~~A) Point A~~
B) Point B
~~C) Point C~~
D) Point D
E) We need more information.

B is closest ??

R to

5) (5 points) A second metal sphere that is identical to the first, except it is initially uncharged, is then briefly touched against the first sphere. The spheres are then separated as shown. Rank the magnitudes of the electric flux through the Gaussian surfaces shown.



A) $|\Phi_{E,A}| = |\Phi_{E,B}| = |\Phi_{E,C}|$
B) $|\Phi_{E,B}| < |\Phi_{E,A}| = |\Phi_{E,C}|$
C) $|\Phi_{E,B}| = |\Phi_{E,C}| < |\Phi_{E,A}|$
D) $|\Phi_{E,A}| = |\Phi_{E,B}| < |\Phi_{E,C}|$
E) We need more information.

Total of +

6) (5 points) With the two spheres separated by 1 cm you measure the magnitude of the force between the spheres to be F_{12}. Now you remove the second sphere, and then bring a third identical sphere that is initially uncharged into brief contact with the first sphere before separating them by 1 cm. What is the approximate magnitude of the force between the first and third spheres?

A) F_{12}
B) $F_{12}/2$
C) $F_{12}/4$
D) 0
E) We need more information.

1/2 q on A ← 1/4 q^2

1/2 q on B

1/4 q on A 1/16 q^2

1/4 q on B so 1/4

q q q^2

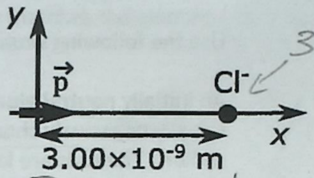
q/2 q/2 $q^2/4$

Dipole = 6.17×

Name Halliman Skyler Student ID 1732227 Score ______
last first

Dipole: − to +

7) (5 points) The dipole moment of the water molecule (H_2O) is 6.17×10^{-30} C·m. Consider a water molecule located at the origin whose dipole moment, $\vec{d}$, points in the positive x direction. A chlorine ion (Cl^-), of charge -1.60×10^{-19} C, is located at $x = 3.00 \times 10^{-9}$ m. Assume that this x value is much larger than the separation between the charges in the dipole, so that the approximate expression for the electric field along the dipole axis can be used. What is the magnitude of the electric **force** that the water molecule exerts on the chlorine ion?



3×10^{-9}

Don't think so

A) 9.86×10^{-22} N
B) 3.29×10^{-13} N
C) 6.57×10^{-13} N
D) 2.05×10^{6} N
E) 4.11×10^{6} N

$$\frac{-1.60\times10^{-19}}{(3\times10^{-9})^2}$$

Electric force on Cl by water

$$\frac{2kp}{|y^3|} = \frac{2(6.17\times10^{-30})(-1.6\times10^{-19})}{(3\times10^{-9})^3}$$

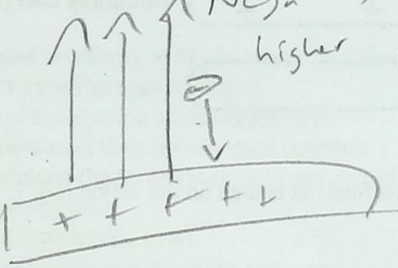
8) (5 points) A negatively charged particle is placed at rest in an electric field. Here are four statements about the subsequent motion.

i. The particle starts moving towards lower potential.
ii. The particle starts moving towards higher potential.
iii. The potential energy of the particle and system of charges creating the electric field decreases as the particle moves.
iv. The potential energy of the particle and system of charges creating the electric field increases as the particle moves.

Which of the above statements are correct?

A) i and iii
~~B) i and iv~~
C) ii and iii
~~D) ii and iv~~

Negatively move towards higher potential

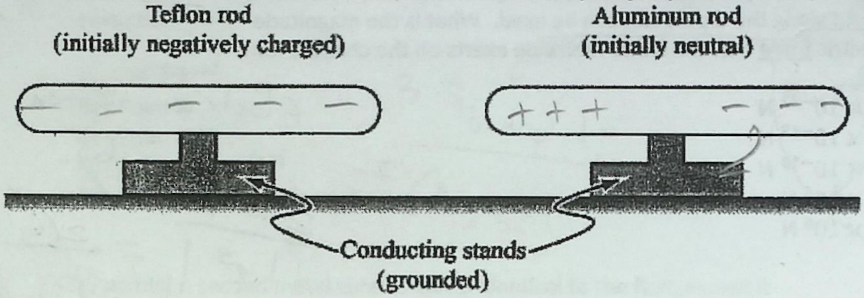


Name Hallinan Skyler Student ID 1732227 Score ______
last first

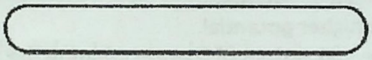
II) Lab multiple choice (16 points total)

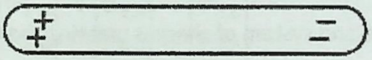
Use the following situation for the next two problems.

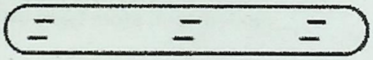
An initially **neutral aluminum** rod is on **conductive and grounded** stand. Then a student places an initially **negatively charged Teflon** rod on a **conductive and grounded** stand near the Aluminum rod, as shown. The rods are kept far enough apart such that no spark jumps.

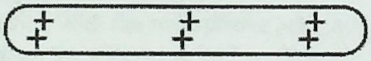


9) (4 points) Choose the image that best depicts the final charge distribution on the aluminum rod.

A. 

B.  Equal amount of + and - charge

C.  Uniformly charged

D.  Uniformly charged

E. 

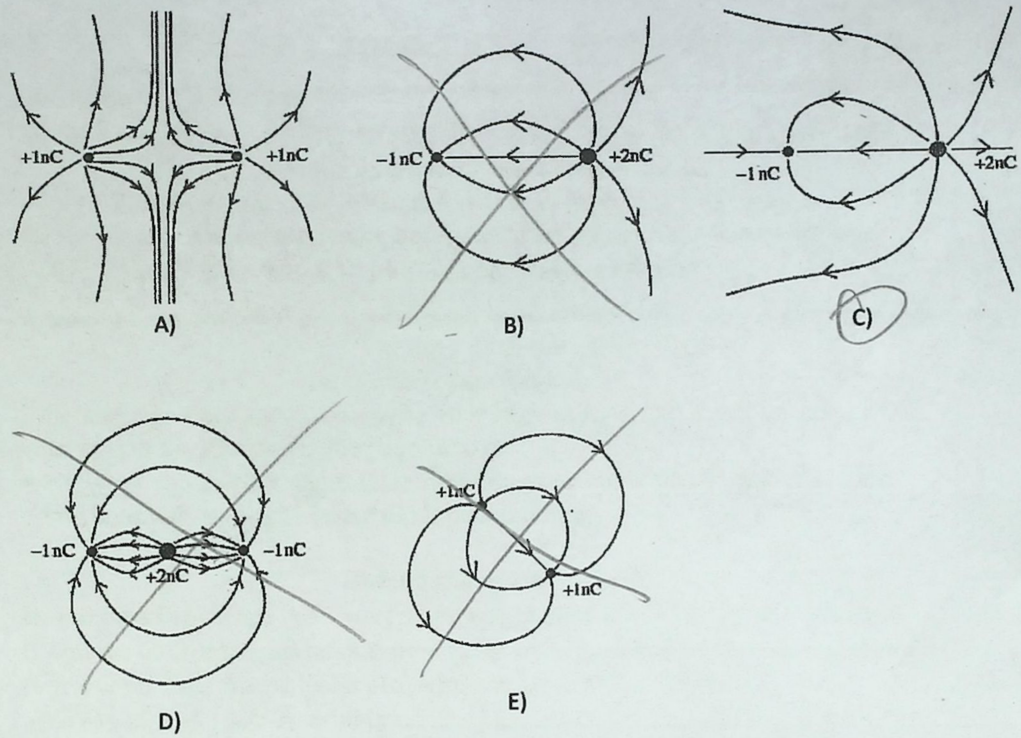
10) (4 points) What is the final net charge on the Teflon rod.

A. Positive
B. Negative
C. Zero
D. Cannot be determined

Name Hallinan Skyler Student ID 1732227 Score______

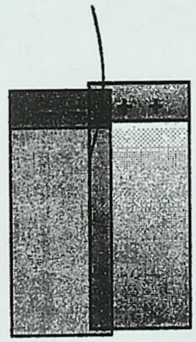
last first

11) (4 points) Which one of the following drawings do you think most closely matches the electric field lines that you would expect for the charge distributions given?



12) (4 points) In the lab you created an electric field "compass" by following these steps:

i. Stick a piece of Scotch tape flat against a table.
ii. Stick a second piece of Scotch tape on top of the first.
iii. Remove both pieces ensuring they remain stuck together.
iv. Lightly rub your hand along the Scotch tape until you do not see the Scotch tape bend towards you.
v. Pull the two pieces of Scotch tape apart.
vi. Stick the two pieces of Scotch tape together as shown.



Which of the following statements about this process is/are correct?

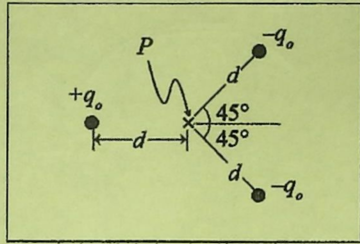
A) Step iv removes the excess charge from the pieces of tape.
B) ~~Step iv makes the Scotch tape have an excess charge.~~ .
C) Step v separates charge from one piece of tape to the other.
D) A and C
E) None of the above.

Name Hallinan Skyler Student ID 1732227 Score 13

last first

IV. [18 pts] The tutorial portion consists of two independent parts: A and B.

A. Three point charges are placed at distances *d* away from point *P*, as shown at right. The negative charges are placed 45° from the horizontal.



Let E_+ represent the magnitude of the electric field at point *P* due to the positive charge alone, E_- represent the magnitude of the net electric field at point *P* due to the two negative charges combined, and E_{net} represent the magnitude of the net electric field due to all three charges combined.

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

6

1. [6 pts] Is E_- from both negative charges combined *greater than*, *less than*, or *equal to* E_+? If there is not enough information, state so explicitly. Explain your reasoning.

E^+ points to right since it is a positive particle: $E_+ = \frac{kq}{d^2}$

The E- from each of the negative charges both point towards the charge since they are negative charges. We see the vertical components are exactly opposite and cancel out (because they are same charge and distance away). Therefore $\nearrow (\longrightarrow \uparrow) + \searrow (\longrightarrow \downarrow) = \longrightarrow$. So the horizontal components sum and point in same direction as $E+$.

$E_{q-} = \frac{kq}{d^2}$, Horizontal comp: E_{q-} (x comp) $= \frac{kq}{d^2\sqrt{2}}$. Multiply by 2 for both charges: $\frac{2kq}{d^2\sqrt{2}}$. We see $2kq/d^2\sqrt{2} > kq/d^2$, so $E^- > E^+$

2. [6 pts] Is E_{net} from all three charges *greater than*, *less than*, or *equal to* E_+? If there is not enough information, state so explicitly. Explain your reasoning.

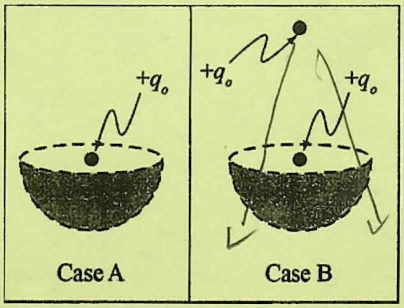
6

$E_{Net} > E_+$, E_{Net} is E from all three point charges. E from +q points in right direction. As proven above, the sum of E from the -q charges also points to the right, and therefore adds to the net field positively: $\longrightarrow + \nearrow + \searrow = \longrightarrow + \longrightarrow = \longrightarrow$

Because E_{Net} is the sum of two vectors in the same direction with positive magnitudes, E_{Net} is larger than the components that made up its sum. Therefore $E_{Net} > E_+$

B. [6 pts] In both cases A and B, a positive charge with charge $+q_o$ is placed at the center a hemispherical shell with no top, as shown at right. In case B, a second positive charge with charge $+q_o$ is placed some distance above the first charge.

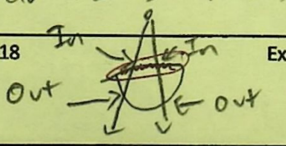
1



Let Φ_A represent the electric flux through the hemispherical shell in case A, and flux Φ_B represent that in case B.

Is the absolute value of Φ_A *greater than*, *less than*, or *equal to* the absolute value of Φ_B? If there is not enough information, state so explicitly. Explain your reasoning.

Field lines from the additional $+q_0$ charge above in Part B will both enter and leave the hemispherical shell, so the net flux from that charge will be 0. Therefore $\Phi_A = \Phi_B$. Field lines go to infinity/negative charge, and there is no - charge, so all that enter leave.



$\emptyset = \epsilon_A$

Name Hallinan Skyler **Student ID** 1732227 **Score** 24

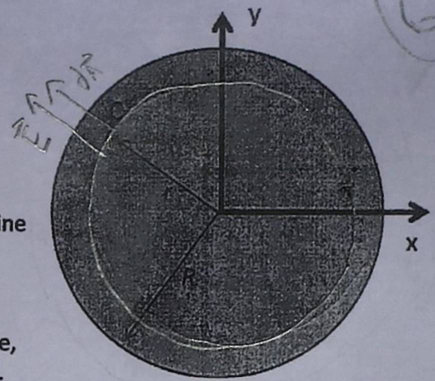
last *first*

III) Lecture free response (26 points total)

Show enough work to get partial credit.

As shown in the figure, you are given a solid **insulating** sphere of radius R with uniform volume charge density $\rho < 0$.

Dark sphere



A. (5 points) Draw a Gaussian surface that can be used to determine the magnitude of electric field when $r < R$ at point C.

5

Sphere that goes through point C

B. (5 points) What is the charge enclosed by your Gaussian surface, in terms of ρ, r, R, and constants? Briefly explain your answer.

$\rho = \frac{q}{V}$

Charge density = ρ

→ Total charge on sphere = Volume in Gaussian surface × charge density

Volume of sphere → 5 $V = \frac{4}{3}\pi r^3 \rightarrow q = \rho V$

Radius of Gaussian surface is r.

$$\boxed{q = \frac{4}{3}\pi r^3 \rho}$$ ← Substitute

3 C. (5 points) At one point on your surface, draw and clearly label $\vec{E}$ and $d\vec{A}$.

(Same direction) $(\emptyset = 0)$

D. (11 points) Use Gauss's law to determine the magnitude $E(r)$ in terms of variables given and constants when $r < R$.

$$\emptyset_{Net} = \oint \vec{E} \cdot d\vec{A} = EA = \frac{q_{enc}}{\epsilon_\emptyset}$$

We can do this because uniform field and because $d\vec{A}$ and $\vec{E}$ in same direction $(\emptyset = 0)$

$q_{enc} = \frac{4}{3}\pi r^3 \rho$

$A = 4\pi r^2$

of sphere (Surface Area)

Substitute:

$$EA = \frac{q_{enc}}{\epsilon_\emptyset}$$

$$E(4\pi r^2) = \frac{\frac{4}{3}\pi r^3 \rho}{\epsilon_0}$$

11

$$E = \frac{4/3\, \pi r^3 \rho}{4\pi r^2 \epsilon_\emptyset}$$

$$\boxed{E = \frac{r\rho}{3\epsilon_\emptyset}}$$