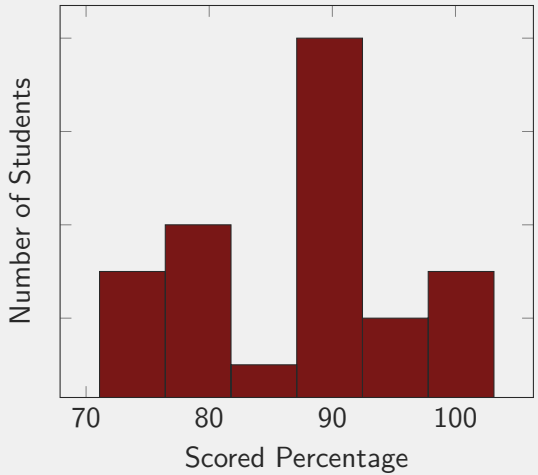
Announcements

- Homework
  - Online HW9 is due tonight!
  - Webwork HW10 will be due on Friday and posted this afternoon
- Tests coming back to you!
  - I ended up not directly adding points, but just being generous with points on the last 2 problems.
- Aiming to get grade reports published by the end of the week now
- Polling: `rembold-class.ddns.net`

Test Discussion



- High: 103%
- Mean: 87.4%
- Std: 9.25%
- Median: 89%

Question 1

Violet Parr has created a position dependent electric field in a quest to defeat Syndrome, given by

$$E(x, y, z) = \langle 5x, 10y, 5z \rangle \, \mathrm{N/C}$$

Violet then places a 2 kg object with a charge of 100 mC at the point $\langle 4, 2, 4 \rangle$m and with an initial velocity of $\langle 1, 2, 0 \rangle$m/s. Where is the particle located two seconds later? You can use intervals of 1 second and can assume that no gravity or drag forces are present.

Question 2

Baby Jack-Jack is playing with a charged set of conducting alphabet blocks. Having strange powers, we'll assume that his hands are fully insulated from the charged blocks and that each block has an identical amount of surface area. The A block initially has a charge of 14 mC, the B block a charge of -4 mC, and the C block is initially neutral. Jack-Jack then undergoes the following sequence of actions:

A. Touches block B to block C
B. Separates blocks B and C, and then momentarily grounds block B
C. Touches blocks A and C
D. Separates blocks A and C, and then momentarily grounds block C
E. Touches all 3 blocks together in such a way that all have equally exposed surface area, and then separates them

Question 3

Dash Parr drags his feet a bit as he sprints across a shaggy carpet, acquiring a net positive charge. Upon stopping he finds himself covered in a fine sheen of dust that is sticking to his body. Comment on any possible net charge of the dust (positive, negative, and/or neutral), and justify why the non-conducting dust would feel a net attractive force in each instance.

Question 4

The Omnidroid "views" the world around it through delicate sensing of electric fields. Running an advanced version of Glowscript, it simulates a distribution of charge, calculates the corresponding electric field, and then compares that to its measured electric field to predict where things are at in the world. Unfortunately for it, when Bob Parr ripped into the Omnidroid with its own claws, some memory banks were wiped out. Fill in the missing lines of code below to correctly calculate the electric field at the point $\langle 3, 1, 0 \rangle$ m due to the 2 m tall, thin, and for some reason positively charged Frozone.

Question 5

Syndrome's newest invention utilizes two dipoles to create a strong electric field at a particular point. The dipole moments of both dipoles are given by:

$$\vec{\mathbf{p}}_1 = \langle 2, 0, 0 \rangle \, \mathrm{C\,m}$$
$$\vec{\mathbf{p}}_2 = \langle -2, 0, 0 \rangle \, \mathrm{C\,m}$$

Both dipoles are centered on the corresponding locations given by:

$$\vec{\mathbf{r}}_1 = \langle 0, 3, 0 \rangle \, \mathrm{m}$$
$$\vec{\mathbf{r}}_2 = \langle 3, 0, 0 \rangle \, \mathrm{m}$$

What is the magnitude and direction of the electric field at the origin?

Question 6

Syndrome's secret base security system utilizes a large, charged floor ($\sigma = 5\,\text{mC/m}^2$) to ward off interlopers. 10 m above the floor, a highly charged ($\lambda = 20\,\text{mC/m}$) narrow monorail track runs parallel to the floor. Elastigirl has blown herself up into a balloon and acquired a slight negative charge of $-10\,\text{mC}$ in the hopes of floating between the rail and floor. If Elastigirl has a mass of 50 kg, at what height would she float *above the floor?* You can assume that she is far from the edges of either the charged rail or the charged floor.

Extra Credit

The Underminer places a large block of neutral metal into an electric field with a strength of 100 N/C. After the system comes to equilibrium, one side of the metal has a slight positive surface charge density, and the other side a slight negative surface charge density. Explain why this is the case, and estimate the positive surface charge density, assuming you are looking at a region far from the edges of the piece of metal.

Review Question

An electric field is given by

$$\vec{\mathbf{E}} = \left\langle xy\cos\left(y^4\right), y\sin\left(y^2\right), 0\right\rangle \,\mathrm{V/m}$$

A 10 g, 2 mC particle moves through the electric field starting at $\langle 0, 4, 0\rangle$. The particle is initially traveling downward at 24.658 cm/s and comes to a stop at $\langle 0, 2, 0\rangle$. Assuming there is zero gravity, what is the change in potential of the particle as it moves through the electric field?

A. $-152\,\mathrm{mV}$

B. $304\,\mu\mathrm{V}$

C. $152\,\mathrm{mV}$

D. $-152\,\mathrm{V}$

Solution: 152 mV

Dipole Potentials

Use two different techniques to calculate the potential due to a dipole with charge $2e$ and separation of 10 nm at a point 5 cm from the center of the dipole and perpendicular to its axis.

Solution: Superposition: 0 V, Integration: 0 V