

Name:

StudentID:

Practice Final, Physics 1B

- Please write your name and UID on the front page, if you separate pages or use extra paper please write your name and UID on each one of them.
- Closed book, **two** 5x3in note cards in your own writing allowed.
- calculators allowed, no laptops or smartphones
- If a problem is ambiguous, notify the instructor. Clarifications will be written on the blackboard. Check the board occasionally.
- Time for exam: 3 hours
- There are 7 questions, check that your exam has all n sheets.

Good Luck !!

Please do not write in this box

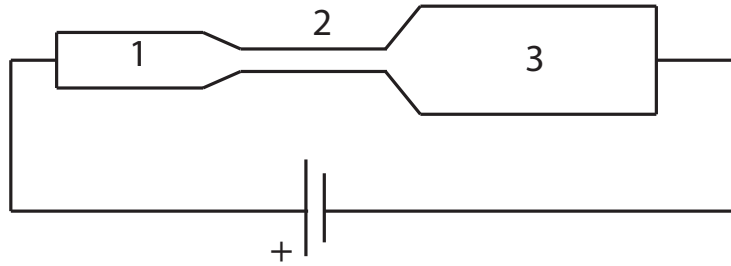
Problem	Points	of Total
1		30
2		30
3		30
4		20
5		30
6		30
7		20
Total		190

Useful quantities

$$\begin{aligned}\epsilon_0 &= 8.85 \times 10^{-12} C^2 m^{-2} N^{-1} \\ g &= 9.81 m/s^2 \\ m_{electron} &= 9.11 \times 10^{-31} kg \\ m_{proton} &= 1.67 \times 10^{-27} kg \\ q_e &= -1.602 \times 10^{-19} C\end{aligned}$$

Problem 1: [25pts] Concept questions

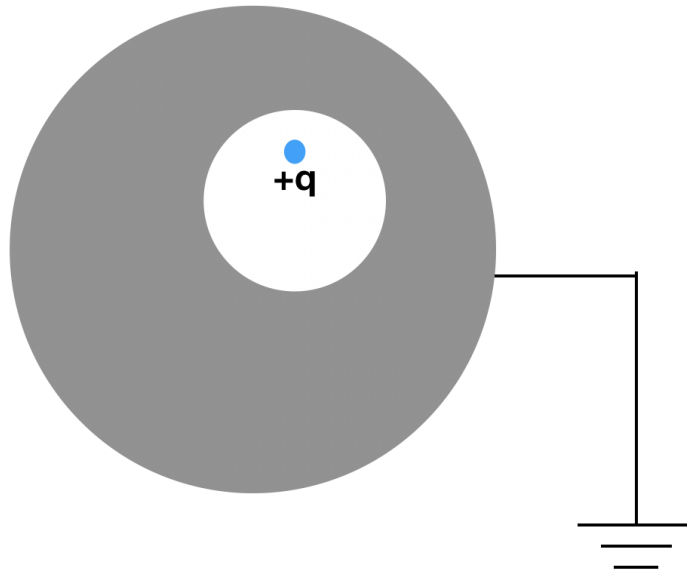
a) [5pts] A resistor is made up of three cylindrical segments of stainless steel (The figure shows a cross section of the resistor). Segment 1 has radius r and length L , segment 2 has radius $r/2$ and length L , segment 3 has radius $2r$ and length $2L$. A battery is connected as shown.



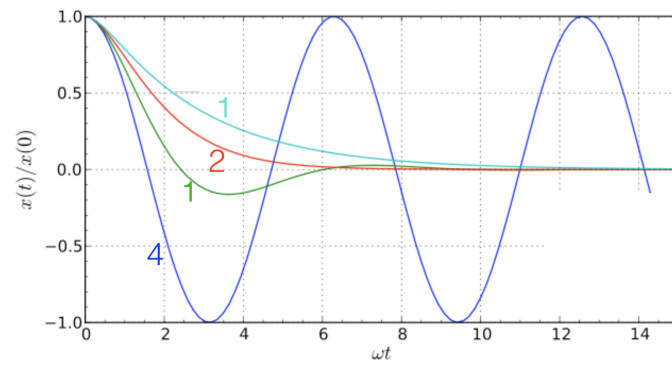
Rank the resistance

- (1) $R_1 = R_2 = R_3$
- (2) $R_2 > R_1 > R_3$
- (3) $R_2 > R_3 > R_1$
- (4) $R_1 > R_2 > R_3$
- (5) $R_3 > R_1 > R_2$

b) [5pts] A conducting sphere has an internal spherical cavity which is offset from the center of the sphere. Inside the cavity, but offset from the center of the cavity, I place a positive point charge $+q$. The conducting sphere is connected to ground via a thin wire as shown. Draw a qualitative picture of the location of charges in the conductor and on the surfaces of the conductor.



c) [5pts] Consider the the plot below, showing position versus time for four damped oscillators. All four have the same mass and spring constant, but have different damping coefficients. In which case is the damping coefficient the largest?



- (1)
- (2)
- (3)
- (4)

d) [5pts] For which of the following displacement functions for sinusoidal waves is the speed of wave propagation the largest?

(1) $u(x, t) = 5 \cos \left(\frac{1}{2}(6x - 4t + 3) \right)$

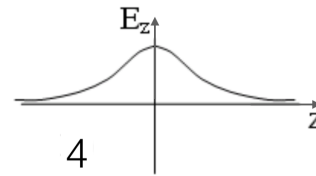
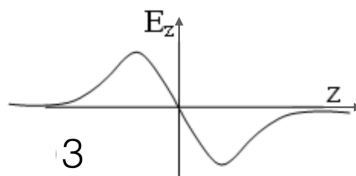
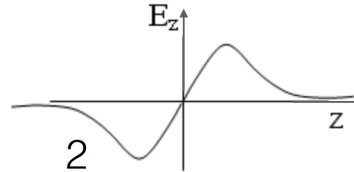
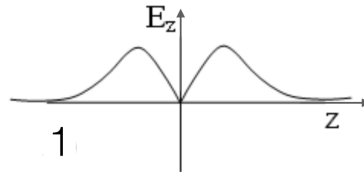
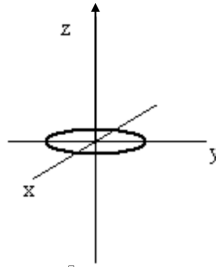
(2) $u(x, t) = 12 \sin(3x + t)$

(3) $u(x, t) = 42 \cos(53x - \frac{1}{10}t + 73)$

(4) $u(x, t) = 6 \sin(3x - t - 1)$

(5) $u(x, t) = 5 \cos \left(\frac{1}{20}x + 3t + 3 \right)$

e) [5pts] A circular uniformly charged ring with positive charge Q is placed in the xy -plane as shown in the figure. Which graph most accurately represents the electric field component E_z on the z -axis ?



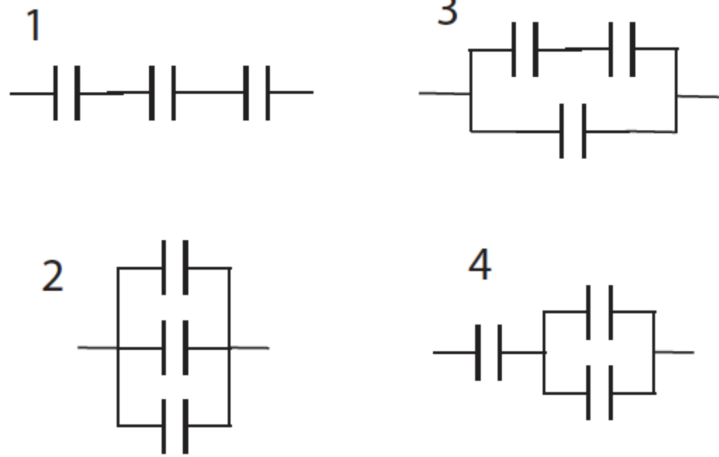
(1)

(2)

(3)

(4)

f) [5pts] I have three capacitors with equal capacitance. Which of the below arrangements of these three will result in the most stored energy if I give each arrangement the same amount of charge (i.e. I connect a battery for just long enough to transfer the same amount of charge Q from the right terminal to the left)

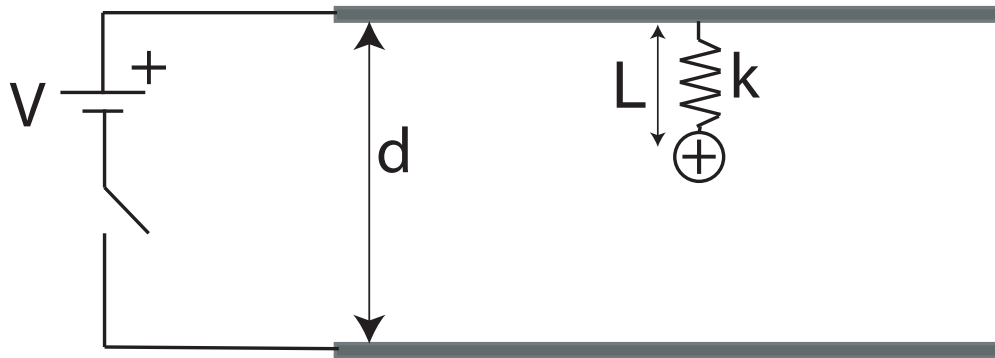


- (1)
- (2)
- (3)
- (4)
- (5) They all store the same amount of energy

-additional space for calculation-

Problem 2: [30pts]

An insulating spring of spring constant k is attached to one plate of a parallel plate capacitor. A charged sphere of mass M and charge $+q$ is attached to the spring. The capacitor plates are initially uncharged and the spring is at its unstretched length, L . (Note: (1) the sides of each plate are much much longer than the separation between the plates, d ; (2) there is no gravity; (3) you can treat the charged sphere as a point particle)



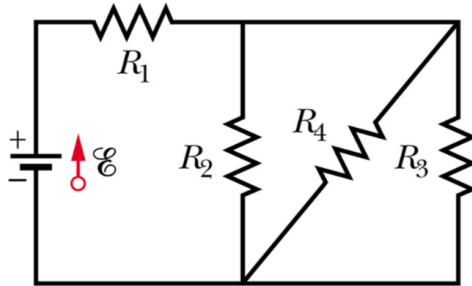
The charged sphere is held in place so that the spring remains unstretched and the switch is closed and the capacitor is connected to a ideal battery with emf V . After a long time, the capacitor is charged and the switch is opened again. The charged sphere is then released and begins to oscillate.

- a) [10pts] What is the frequency of the oscillation?
- b) [10pts] What is the amplitude of the oscillation ?
- c) [10pts] The plates are moved apart (with the switch open) so that their new separation is $2d$. What happens to the amplitude of the oscillation?

-additional space for calculation-

Problem 3: [30pts]

The ideal battery with EMF ϵ is connected as shown in the figure to the three resistors, $R_1 = R_2 = R_3 = R_4 = R$.



- a) [10pts] Find the resistance of a single equivalent resistor that replaces the four resistors.
- b) [10pts] What is the current in resistor R_1 ?
- c) [10pts] What is the power released in resistor R_4 ?

-additional space for calculation-

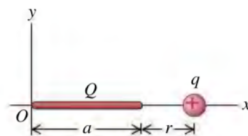
Problem 4: [20pts] A stationary siren gives of a pure sine-wave with frequency $f = 700Hz$ and is opposite a wall 20m away. Assume the speed of sound is $v_s = 340m/s$.

a) [10pts] A microphone is moved with velocity $v_1 = 5m/s$ away from the siren towards the wall. What is the frequency the microphone picks up for the wave coming directly from the microphone and the reflected wave from the wall ?

b) [10pts] The microphone now moves with an unknown velocity v_2 . When you play the recording of the microphone you hear a beat frequency of $f_b = 1.5Hz$. What is v_2 ?

-additional space for calculation-

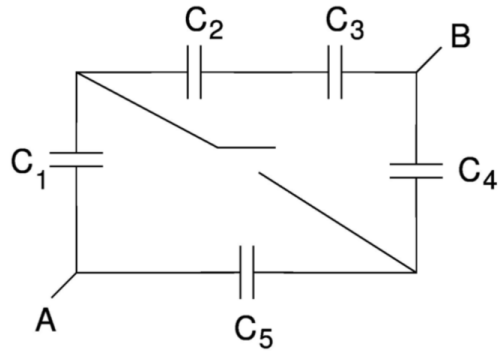
Problem 5: [30pts] Positive charge Q is distributed uniformly along the x -axis from $x = 0$ to $x = a$. A positive point charge q is located on the positive x -axis at $x = a + r$, a distance r to the right of the end of Q as shown in the figure.



- a) [10pts] Calculate the x - and y -components of the electric field produced by the charge distribution Q on the points on the positive x -axis where $x > a$.
- b) [10pts] Calculate the force (magnitude and direction) that the charge distribution Q exerts on q .
- c) [10pts] Show that if $r \gg a$, the magnitude of the force in part (b) is approximately $\frac{Qq}{4\pi\epsilon_0 r^2}$. Explain why this result is obtained.

-additional space for calculation-

Problem 6: [30pts] All capacitors have the same capacitance $C_i = C, i = 1, 2, 3, 4, 5$. Express all answers in terms of the capacitance C .

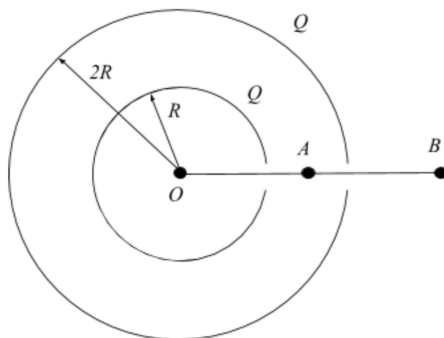


- a) [10pts] Calculate the equivalent capacitance between points A and B when the switch is open.
- b) [10pts] Calculate the equivalent capacitance between A and B when the switch is closed.
- c) [10pts] If the potential difference $V_{AB} = V$ is applied between points A and B when the switch is open, what is the charge Q_1 on capacitor C_1 after all capacitors are charged ?

-additional space for calculation-

Problem 7: [20pts] Two concentric thin non-conducting spherical shells have radii R and $2R$, and each has a small hole along the line OB as shown. Each shell carries a positive charge Q , uniformly distributed with a constant charge density.

Assume $R = 0.5m$ and $Q = 0.04C$.



a) [10pts] What is the electric potential at point A , at distance $3R/2$ from the center, assuming the potential is zero at infinity? (Any effect of the holes should be neglected.)

b) [10pts] A proton with charge q_p and mass m_p is released from point O in the direction of point B with an initial speed $v_0 = 200m/s$. What is the speed of the proton at point B at distance $3R$ from the center? (Assume the motion is non-relativistic, and there are no forces other than the electrostatic forces.)

-additional space for calculation-