1B1-S21 Quiz A Final

[redacted]

TOTAL POINTS

53.5 / 55

QUESTION 1

1 boat 15 / 15

✓ **- 0 pts Correct**

- 1 pts wrong conclusion

QUESTION 2

sphere 20 pts

2.1 sketch 14.5 / 16

- 0 pts Correct

$$|E|$$

- 3 pts Wrong

- 0.5 pts Graph has wrong sign of slope at some parts

- 0.5 pts Incorrect behavior for $$|x|>R_4$$

- 0.5 pts Lack of discontinuity at $$|x|=R_3$$

- 0.5 pts Wrong sign of jump at $$|x|=R_2$$

$$U$$

- 3 pts Wrong

✓ **- 1 pts Curves/cusps in wrong directions or there are no curved sections**

- 1.5 pts Incorrect behavior between $$R_1$$ and $$R_2$$

- 0.5 pts Incorrect behavior for $$|x|>R_4$$

- 0.5 pts Discontinuous

- 0.5 pts Sign error

$$K$$

- 3 pts Wrong

- 0.1 pts Graph reaches $$0$$ in the middle

✓ **- 0 pts Roughly correct based on shape of $$U$$**

- 1 pts Curves/cusps in wrong directions

$$\sigma$$

- 3 pts Wrong (e.g., graph is not localized to a few specific values of $$x$$)

- 1 pts Some points have wrong magnitudes, or number of nonzero points is wrong

✓ **- 0.5 pts Not sharply localized**

2.2 charge on shell 2 / 2

✓ **- 0 pts Correct**

- 1.5 pts Incorrect with attempted justification

- 1 pts Wrong sign

- 0.2 pts Misinterpreted the question and instead indicated the charge on the outer surface of the outermost shell

2.3 charge on inner surface 2 / 2

✓ **- 0 pts Correct**

- 1.5 pts Incorrect with attempted justification

- 1 pts Wrong sign

QUESTION 3

circuit 20 pts

3.1 power at t=0 5 / 5

✓ **- 0 pts Correct**

- 1.5 pts not short circuiting C3

- 1 pts wrong current through R_1

- 1 pts wrong current in R_2 (or R_2 and R_3 if incorrectly didn't short circuit)

3.2 charge time 5 / 5

✓ **- 0 pts Correct**

- 4 pts Something like instantaneous

- 1.5 pts wrong time constant

3.3 charge after long time 5 / 5

✓ **- 0 pts Correct**

- 1.25 pts Q_1 different from Q_2

- 1.25 pts both Q_1 and Q_2 wrong

- **1.25 pts** Q_3 wrong

3.4 sketch **5 / 5**

✓ **- 0 pts** **Correct**

- **1 pts** 3/4
- **2 pts** 2/4
- **3 pts** 1/4
- **4 pts** 0/4, but attempt

1B Spring 2021: FINAL

Show all your work and use proper units throughout. This final is open-book but not open-Chegg and must be completed without help. Please write your answers into the boxes. If you submit your work with your own formatting please try to submit the same number of pages as the template. You have 24 hours to submit your answers.

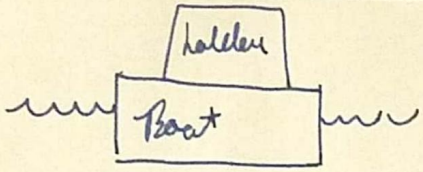
1. Please complete part A of this final on KUDU. (30 points)!

Problem 2

(15 points)

A boat floats on a lake and carries a large boulder. When you throw the boulder overboard into the water so that it sinks, will the water level of the lake sink, rise, or stay the same?
EXPLAIN your answer in detail using the appropriate equations.

(1)



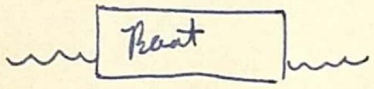
$F_b = V_{displ\ H_2O\ displ\ 1} \cdot \rho_0 \cdot g$

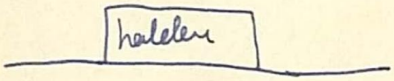
$F_g = g(V_{boat}\,\rho_{boat} + V_{boulder} \cdot \rho_{boulder})\,g$

$F_b = F_g \rightarrow V_{H_2O\ displ\ 1} = \frac{\rho_{boat}}{\rho_0} V_{boat} + \frac{\rho_{boulder}}{\rho_0} V_{boulder}$

$\rho_0 \rightarrow \rho_{water}$

(2)





$F_b = V_{H_2O\ displ\ 2} \cdot \rho_0 \cdot g$

$F_g = g\, V_{boat}\, \rho_{boat}$

$F_b = F_g \rightarrow V_{H_2O\ displ} = \frac{\rho_{boat} \cdot V_{boat}}{\rho_0}$

$\text{total } H_2O \text{ displ} = \frac{\rho_{boat} V_{boat}}{\rho_0} + V_{boulder}$

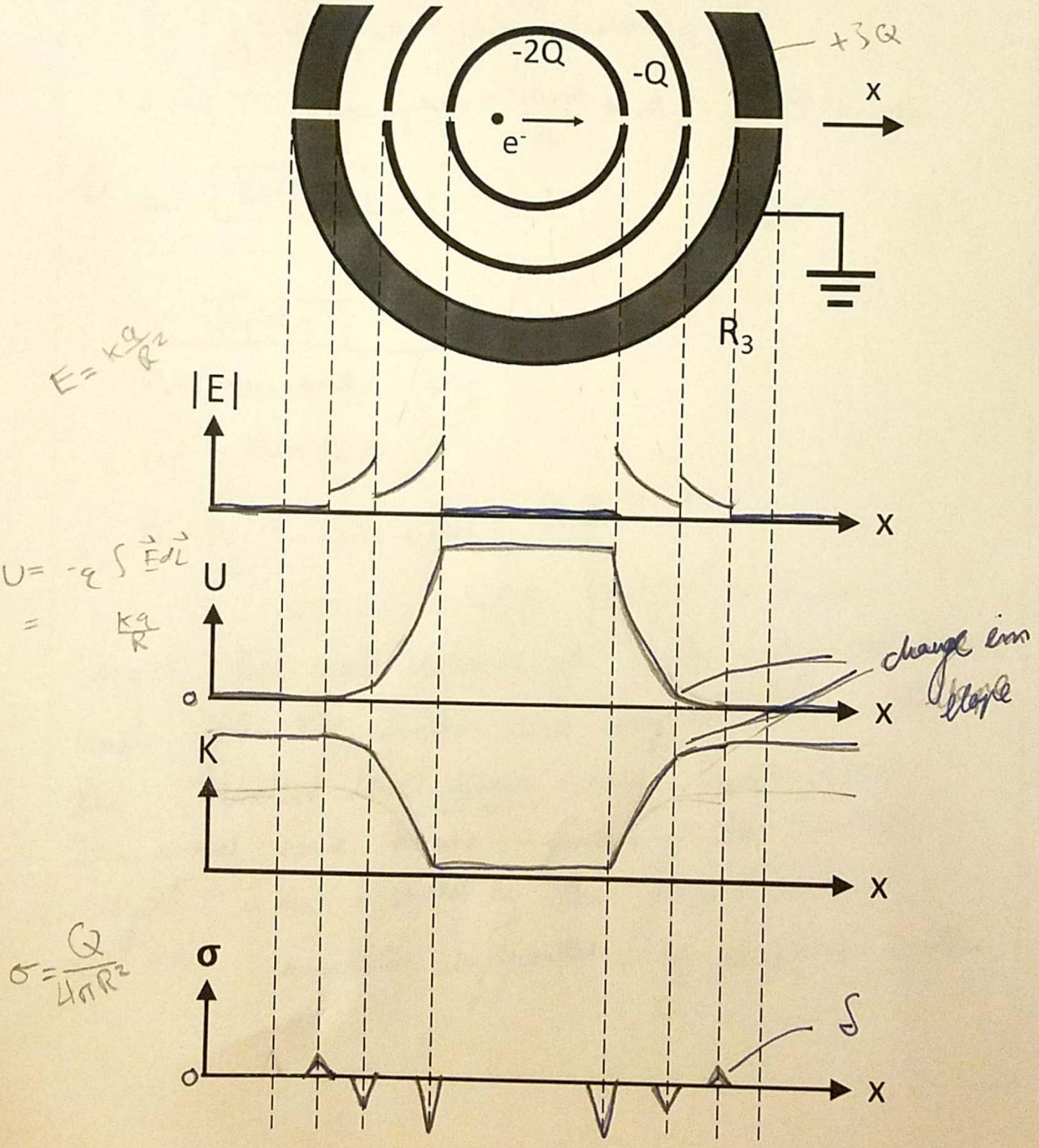
comparing the ~~vol~~ volume of water displaced before and after the boulder was dropped, shows that the water level sank since $\rho_{boulder} > \rho_0$.
This makes sense because a portion of the boulders weight is being supported by the ground instead of being completely supported by displaced water.

Problem 3

(20 points)

Consider the spherically symmetric charge configuration shown, consisting of a hollow conducting shell of radius R_1 and charge -2Q, surrounded by air, surrounded by a hollow conducting shell of radius R_2 and charge -Q, surrounded by air, surrounded by a grounded, conducting solid spherical shell of inner radius R_3 and outer radius R_4. Holes are cut through this configuration exactly along the x-axis to allow an electron to pass unobstructed. The electron shown inside R_1 is moving from left to right.

a. Qualitatively correct sketch the magnitude of E, the electric potential energy, the kinetic energy, and the charge density as a function of x everywhere in the graphs. You may assume that Q≫e and so the electric field is not affected by the electron. You may assume that the hole does not break the spherical symmetry. *[16 points]*



b. What is the total charge on the outermost solid spherical shell? Explain. *[2 points]*

+3Q, because electrons will be repulsed by the existing field and flow to ground to make E,0 within ~~and~~ the conducting ~~sphere~~ spherical shell.

If you meant the shell @ R_4, the charge on that is 0 because the sphere is grounded & the induced charges can flow away.

c. What is the charge on the inner surface (R_3) of the outermost solid spherical shell? Explain. *[2 points]*

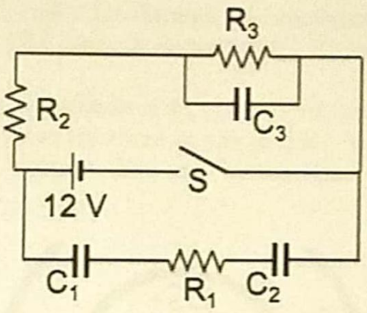
+3Q to cancel out the electric fields from shells within.

$$E_+ = \frac{-K\,3Q}{R_3} + \frac{K\,C}{R_3} = 0 \rightarrow C = 3Q$$

Problem 4

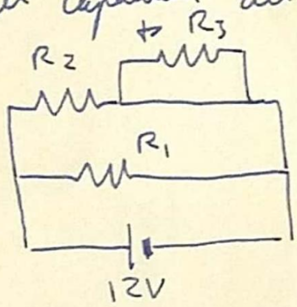
(20 points)

Consider the circuit shown below with three resistors $R_1 = 1.0$ kΩ, $R_2 = 2.0$ kΩ, $R_3 = 3.0$ kΩ, and three capacitors $C_1 = 500$ pF, $C_2 = C_3 = 2.0$ nF.



a. The switch is initially open and all capacitors are fully discharged. You now close the switch. Calculate the power dissipated in each of the three resistors right after the switch is closed but the charges on the capacitors have not yet changed significantly (t=0). *[5 points]*

all capacitors act like wires

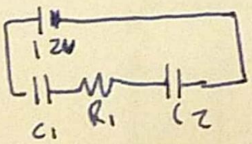


$V_1, V_2 = 12V$
$V_3 = 0V$
$P = IV = \frac{V^2}{R}$
$V = IR$

$P_1 = \frac{(12V)^2}{1.0 k\Omega} = .144 W$
$P_2 = \frac{(12V)^2}{2 k\Omega} = .072 W$
$P_3 = 0$

b. How long does it take until C_1 is charged? Explain. *[5 points]*

it takes about 5 RC time constants



$R = 1.0 k\Omega$

$C = \frac{C_1 \cdot C_2}{C_1 + C_2}$

since both $C_1 + C_2$ are in series they'll charge at the same rate

~~$5 \cdot 1\times10^3 \Omega \cdot 1\times10^{-9} = 5\times10^{-6}$ seconds~~

$C = \frac{500\times10^{-12} F \cdot 2\times10^{-9} F}{2.5\times10^{-9} F} = 4\times10^{-10} F \rightarrow 5 \cdot 1\times10^3 \Omega \cdot 4\times10^{-10} F =$ [illegible] s

$= 2\times10^{-6}$ s 2 milli seconds

c. What are the charges on the capacitors after the switch has been closed a very long time? *[5 points]*

top Current = $\frac{12V}{R_2+R_3} = \frac{12V}{5k\Omega}$

Voltage$_2$ = $\frac{12V}{5k\Omega} \cdot 3k\Omega = 7.2\,V$

$C_3 = \frac{Q_3}{V_3} \rightarrow Q_3 = C_3 \cdot V_3 = 2.0nF \cdot 7.2V = \boxed{14.4\,nC}$

$C_{1,2} = 4\times10^{-10}\,F = .4nF$

$Q_{1,2} = C_{1,2} \cdot V = .4nF \times 12V = \boxed{4.8nC}$

d. Qualitatively correct sketch the following quantities during the charging phase, i.e. from t=0 when the switch is closed until the capacitors are fully charged: 1. current flowing through R_1, 2. The charge on C_1, the current flowing through R_2, and the current flowing through R_3. *[5 points]*