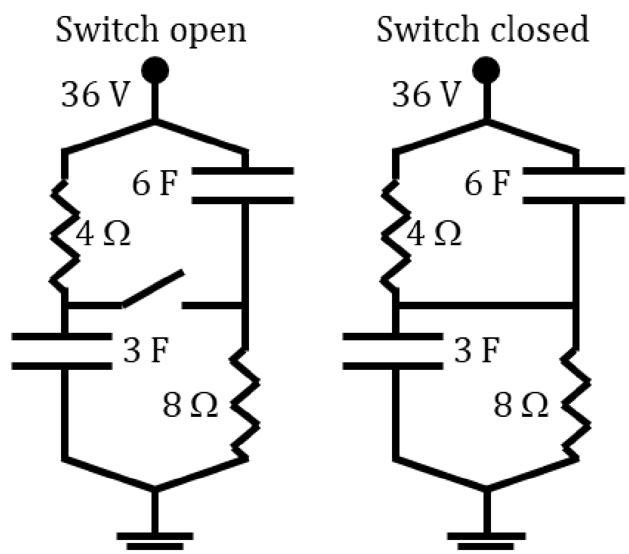
APPC, E & M: Unit B HW 5

Name: ______________________________
Hr: ___ Due at beg of hr on: __________

UB, HW5, P1
Reference Video: "Review of Unit on DC Circuits (Part IV)"
YouTube, lasseviren1, DC CIRCUITS playlist

Refer to the bridge-circuit diagrams at right to determine each of the following quantities. Put correct units on your answers.

SWITCH OPEN:	SWITCH CLOSED:
$I_{4\,\Omega}$ =	$I_{4\,\Omega}$ =
$I_{8\,\Omega}$ =	$I_{8\,\Omega}$ =
$V_{4\,\Omega}$ =	$V_{4\,\Omega}$ =
$V_{8\,\Omega}$ =	$V_{8\,\Omega}$ =
$V_{3\,F}$ =	$V_{3\,F}$ =
$V_{6\,F}$ =	$V_{6\,F}$ =
$Q_{3\,F}$ =	$Q_{3\,F}$ =
$Q_{6\,F}$ =	$Q_{6\,F}$ =



UB, HW5, P2
Reference Video: “Objects Falling with Air Resistance (Part I)”
YouTube, lasseviren1, AIR RESISTANCE AND RC CIRCUITS playlist

In this problem, we will begin to analyze the motion of an object of mass m that is dropped from rest in a fluid. (The fluid might be air, some other gas, or perhaps a liquid.) Let us suppose that the fluid will exert a drag force on the moving mass that is directly proportional to the speed of the mass, i.e., $|F_{drag}| = \beta v$.

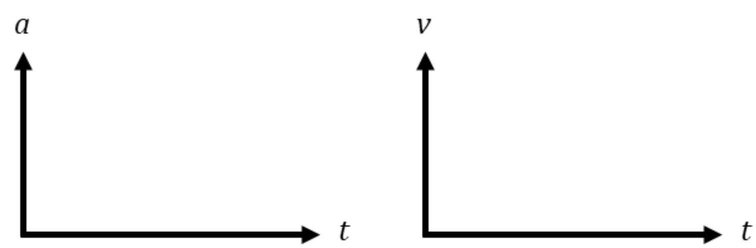
A. Assuming standard SI units, what must be the units on the constant β?

B. In the space above-right, draw a free-body diagram showing the forces acting as the mass falls.

C. At some point during the fall, the mass will achieve terminal speed v_T. Derive an expression for the terminal speed v_T of the mass.

D. Use your Part A answer to show that your Part C answer is dimensionally consistent.

E. In the two graphs shown, use a dashed line (- - -) to sketch how the mass’s acceleration a and speed v would vary with time if there were NO drag force from the fluid. Use a solid line to show how a and v will vary with time when there IS a drag force. Also, on the vertical axis of the appropriate graph, label the values g and v_T.



F. Using Newton’s 2nd law, it is possible to write a differential equation that relates to this situation. Here, write – but do NOT solve – that differential equation.

UB, HW5, P3

Reference Video: "Objects Falling with Air Resistance (Part II)"
YouTube, lasseviren1, AIR RESISTANCE AND RC CIRCUITS playlist

This problem is a continuation of the previous one. Here, you will solve the differential equation you wrote in Part F of Problem 2.

A. Solve your equation of Part F of Problem 2 for the term dt, i.e., dt = ?
Hint: First, divide through by m, then rearrange terms. On the right side of the equation, the denominator will look a bit unusual; namely, it will have multiple terms, one of which has ITS OWN denominator.

B. We will need to integrate both sides, so re-write your Part A answer showing that you will integrate time from $t = 0$ to $t = t$ and that you will integrate velocity from $v = 0$ to $v = v$.

C. Let's use *u-substitution* to solve your Part B equation. Write here what u should be set equal to; namely, the unusual-looking denominator mentioned in Part A.

D. Now, differentiate your Part C answer with respect to v, i.e., find du/dv = ?

E. Solve your Part D answer for dv.

F. Substitute your answers to Parts C and E into your answer to Part B. Be sure to include the same limits of integration mentioned in Part B.

G. Here, do two steps in one: (1) Mentally integrate the LEFT side of your Part F answer (easy!) and (2) move all constants to the left side. Hint: This should leave you with only u-stuff to integrate on the right. Don't show the steps separately; show only one answer.

H. Now, do two more steps in one: (1) Integrate the right side of your Part G answer and (2) un-substitute your Part C answer so that there aren't any more u terms, only v terms. Make sure to include the integration limits on the right side of the equation.

I. Two MORE steps in one: (1) Substitute and evaluate the limits of integration on the right side and (2) use a law of logarithms to represent the limits as a quotient of terms, NOT as a difference.

J. Rewrite your Part I answer, with one modification: On the right side, eliminate the large fraction line so that the thing in parentheses goes something like: "1 – ???"

K. All along, our goal has been to find an equation for the velocity of the dropped mass as a function of time, i.e., $v(t)$. At this point, in your Part J answer, there should be a v tucked inside some kind of logarithm function. Take the necessary step to "un-log" the v term. Remember, this must be done to both sides of your Part J answer.

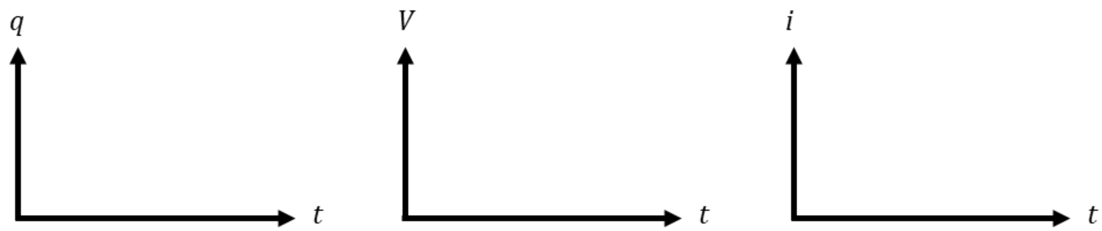
L. Solve your Part K answer for $v(t)$.

M. Based on your Part L answer, write an expression for $a(t)$.

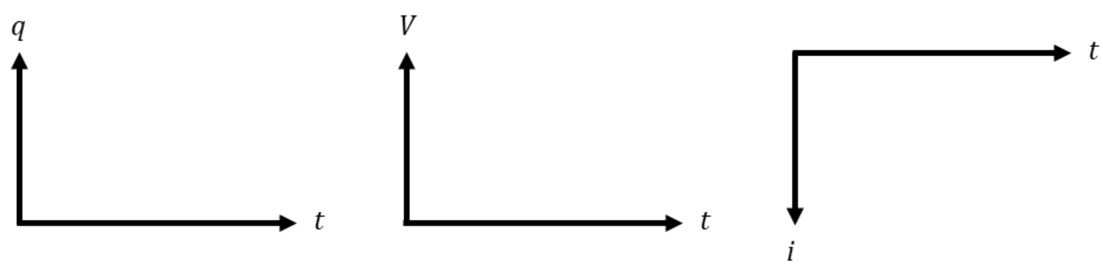
UB, HW5, P4
Reference Video: "Discharging Capacitors"
YouTube, lasseviren1, AIR RESISTANCE AND RC CIRCUITS playlist

For RC circuits, the charge on the plates, the voltage across the plates, and the current in the circuit vary with time, i.e., these can be expressed as functions: $q(t)$, $V(t)$, and $i(t)$…all of which are exponential in format. In the graphs shown, draw approximate curves that represent how q, V, and i vary with time.

A. During charging…



B. During discharging...
Note that we will consider the current during discharge to have (–) values.



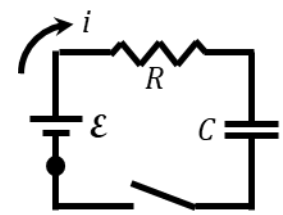
C. It has been observed that all graphs with an $e^{-?}$ term become asymptotically close to some final, constant value. If the asymptotic value is NOT equal to zero, we say it is a *climbing graph* (or *rising graph*), and the equation for such a graph has the term $(1 - e^{-?})$. If the asymptote IS zero, we say it is a *decaying graph* (or *falling graph*), and the equation for such a graph has merely the term $e^{-?}$. Below EACH graph in Parts A and B, write TWO of the following four labels:

$1 - e^{-?}$ **decaying** **$e^{-?}$** **climbing**

UB, HW5, P5

Reference Video: "Charging a Capacitor in an RC Circuit"
YouTube, lasseviren1, AIR RESISTANCE AND RC CIRCUITS playlist

Given: Here, you will derive an equation for $q(t)$ on the plates for a charging capacitor. With reference to the figure, starting at the dot, taking into account the assumed current i, and proceeding clockwise, the Kirchhoff's Loop Equation is: $\varepsilon - iR - V_c = 0$



A. Modify the given equation in two ways:
(1) change i to dq/dt and (2) change V_c to $\frac{q}{C}$.

B. What is it about your Part A answer that makes it a differential equation?

C. Now we will solve your differential equation. Rearrange your Part A answer so that the R and dt terms are the only ones on the left. The right side will look a little strange, in that it will have a fraction in the denominator.

D. We must integrate both sides, so re-write your Part C answer showing that you plan to integrate time from $t = 0$ to $t = t$ and charge from $q = 0$ to $q = q$.

E. We'll use *u-substitution* to solve your Part D equation. Write here what u should be set equal to; namely, the right-side denominator of your Part C answer.

F. Now, differentiate your Part E answer with respect to q, i.e., find du/dq = ?

G. Solve your Part F answer for dq.

H. Substitute your answers from Parts E and G into your answer to Part D. Be sure to include the same limits of integration mentioned in Part D.

I. Here, do two steps in one: (1) Mentally integrate the LEFT side of your Part H answer (easy!) and (2) move all constants to the left side. Hint: This should leave you with only u-stuff to integrate on the right. Don't show the steps separately; show only one answer.

J. Now, do two more steps in one: (1) Integrate the right side of your Part I answer and (2) un-substitute your Part E answer so that there aren't any more u terms, only q terms. Make sure to include the integration limits on the right side of the equation.

K. Two MORE steps in one: (1) Substitute and evaluate the limits of integration on the right side and (2) use a law of logarithms to represent the limits as a quotient of terms, NOT as a difference.

L. Rewrite your Part K answer, with one modification: On the right side, eliminate the large fraction line so that the thing in parentheses goes something like: "1 – ???"

M. At this point, in your Part L answer, there should be a q tucked inside some kind of logarithm function. Take the necessary step to "un-log" the q term.

N. Solve your Part M answer for $q(t)$.