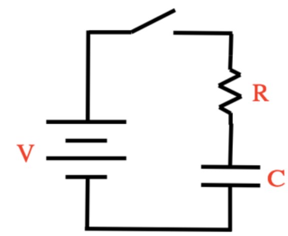
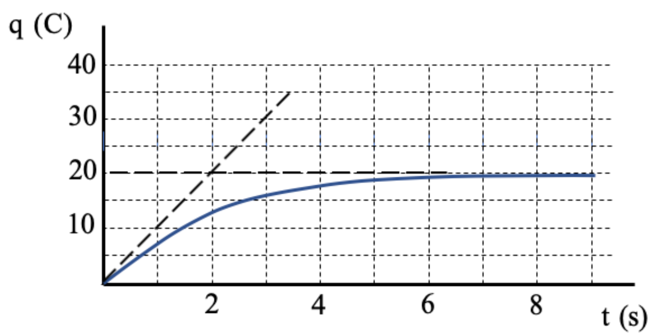
(15 min) A graph of a charging cap in an RC circuit is shown below. The switch was thrown at t = 0. The graph shows the charge drawn from the battery from t = 0 on. The positive values represent positive charge leaving the positive terminal. The dotted lines identify the slope of the graph at t = 0 and the line the graph reaches asymptotically after a long time.





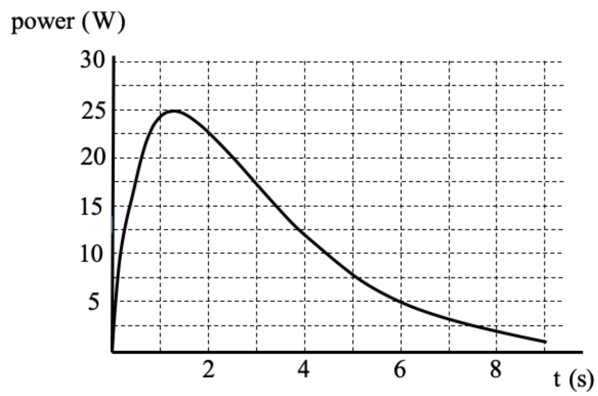
a.) Suggest values for V in volts, R in ohms and C in farads that could have generated the graph. Explain your reasoning.

--when charging, a cap will charge to 63% of its maximum during one time constant, which is equal to RC;
--looking at the graph, q(max) is 20, so .63(20) is 12.6 C;
--12.6 C happens right around the 2.0 second point;
--that means RC = 2.0;
--so R could be 10 ohms and C could be .2 farads;
--we know that after a long period of time, all the voltage will be across the cap, so at that point the battery voltage V = q/C;
--as q = 20 after a long time, assuming C = .2 f, V = 20/.2 = 100 v.

b.) You are asked to create a second graph with twice the initial slope but with the same horizontal asymptote. You have access to one battery of voltage V, one additional resistor R, one capacitor of capacitance C and several additional wires. How could one or more of those elements might be used to affect that task. Justify your response.

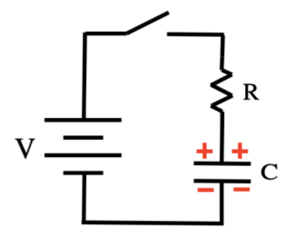
--the slope of this graph is q/t, which is the current in the circuit;
--in a circuit in which there is an uncharged cap, the cap does nothing initially as it is uncharged;
--that means the initial current in the circuit is the same as if there was just the battery and the resistor;
--that initial current's value will be i = V/R;
--to double this, you would have to halve the effective resistance in the circuit;
--a second resistor in parallel with the first would produce a resistance combination the equivalent resistance of which would be R/2;
--q(max) = CV(battery) (this was established in Part a);
--as V hasn't changed and we want q(max) to stay the same (keep the asymptote), nothing has to change as far as the capacitor goes.

c.) A student creates a graph of the power delivered to the cap as a function of time. Explain why the graph starts at zero, reaches a maximum and then asymptotically approaches zero again.



--it takes no energy to charge a capacitor that has no charge on its plates, so the initial power delivered to the cap will be zero;
--as charge accumulates on the cap, it takes more and more power to force more and more charge onto the cap, hence the increase of power delivered;
--as the cap gets close to being completely charged, the current in its branch diminished; as power is a function of current, it is expected that the power delivered will diminish as the current approaches zero.

d.) In a different experiment, a student charges the cap to a voltage that is twice that of the battery with the polarities as shown. Describe how the graph of the charge vs. time at the top of the page would appear now if the switch was closed at t = 0. Be sure to address the initial slope and final asymptote of the graph. Justify your response.



--the charge will begin at twice the value shown on the original graph;
--the capacitor is going to discharge;
--the RC circuit's time constant has not change as neither R nor C have changed;
--the charge will diminish exponentially, asymptotically approaching the charge "q = 20 C" line with time;
--the overall look of the graph would be just like the graph shown in the original sketch, but inverted and terminating along the q = 20 C line;
--it's almost as though V's worth of charge on the cap is nullifying the battery, and a second V's worth of charge on the cap is then doing its discharging thing.