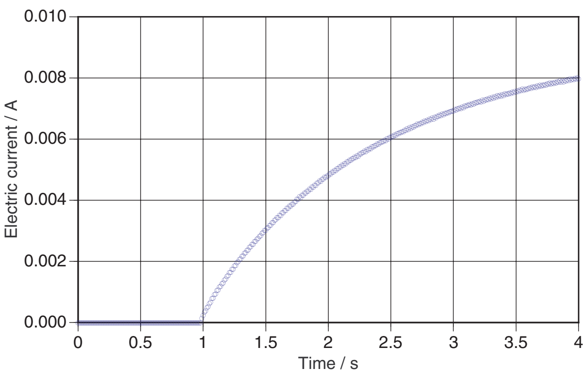
PHYSICS EXAM

1. The data in the graph show the rising electric current in an RL circuit. What is the rate of change of the current at 2.0 s?



❑ about 0.74 A/s
❑ about $2.4{\cdot}10^{-3}$ A/s
❑ about $3.0{\cdot}10^{-3}$ A/s
❑ about $-\,2.4{\cdot}10^{-3}$ A/s
❑ about $3.0{\cdot}10^{-3}$ A
❑ arctan(36.5°) A/s

Explanation:..
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2. Water is flowing out of a tank through a horizontal pipe fitted at the bottom. The pressure at the inlet and the outlet is measured. What does the difference of the pressure values represent at any moment?

❑ The pressure difference because of resistance
❑ The pressure difference from the top to the bottom of the fluid in the tank
❑ The inductive pressure difference
❑ The sum of the resistive and the inductive pressure differences
❑ The pressure difference due to the narrowing of the flow from the tank to the pipe

Explanation:..
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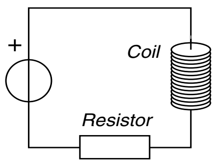
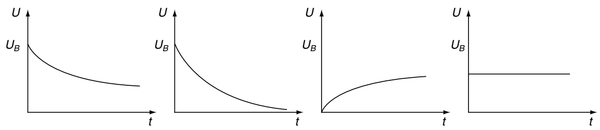
3. A coil made of a long thin copper wire is hooked up to a constant voltage battery and a resistor. The resistances of the resistor and the wire of the coil have similar values.



The circuit is closed at $t = 0$ s and the voltage across the coil is measured. Which of the diagrams represents the measurements best?



❑ ❑ ❑

Explanation:..
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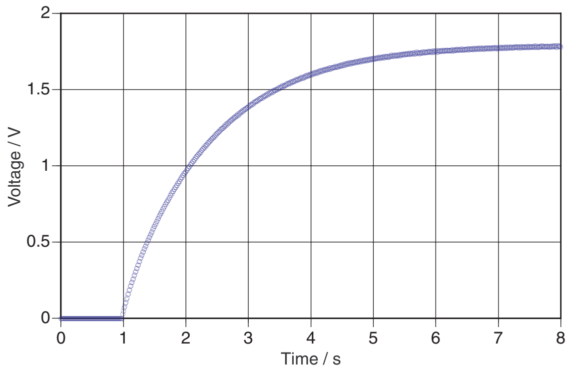
4. A coil and a resistor are hooked up to a constant voltage battery. The inductance of the coil is 630 H. The voltage across the resistor is measured. The diagram shows the data taken during the experiment. What is the total resistance of all resistors in the circuit?



- ❑ close to 0 Ω
- ❑ about 2.1 μΩ
- ❑ about 500 Ω
- ❑ about 820 Ω
- ❑ larger than 820 Ω

Explanation:...
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....
....

5. A 100 μF capacitor is charged to voltage of 10 V. Then it is hooked up to a resistor having a resistance of 100 Ω. The rate of change of the energy of the capacitor at the beginning is

- ❑ – 1.0 J/s
- ❑ – 1.0 W/s
- ❑ 1.0 W
- ❑ – 10 W
- ❑ 0.10 J/s

Explanation:...
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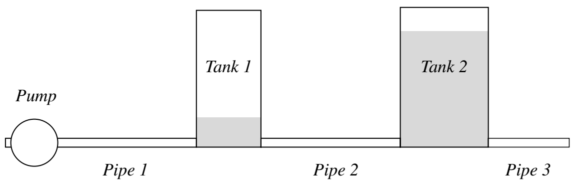
....
....

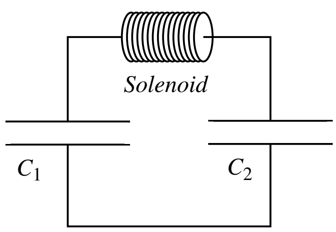
6. An oil tank with a cross section of 1.0 m^2 is filled by a pump through a long horizontal pipe. The tank is connected by another horizontal pipe to a second one with a cross section of 5.0 m^2. This second container has a pipe which leads out into the environment. Initially, the oil levels are 1.0 m and 8.0 m. The flow resistance of the three pipes are $1.0 \cdot 10^6$ Pa·s/m^3, $1.0 \cdot 10^6$ Pa·s/m^3 and $0.5 \cdot 10^6$ Pa·s/m^3. The pump works with a constant pressure difference of 1.0 bar. Assume the density of the oil to be 1000 kg/m^3, and take g = 10 N/kg. Set the ambient air pressure to zero.



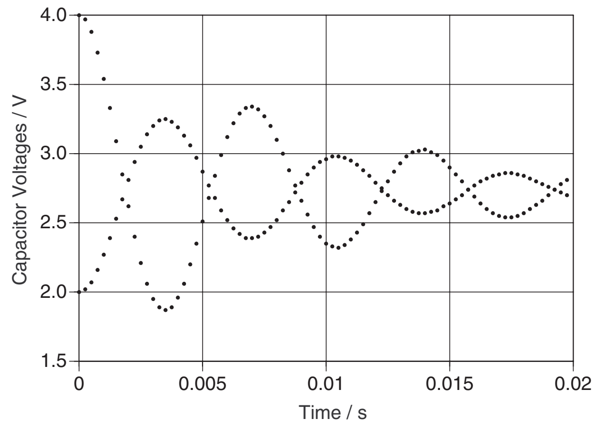
Consider only the initial point in time (just after the pump is turned on). Ignore inductive effects.

a. Determine the three oil currents.
b. What is the power of the pump at that moment?
c. What is the rate with which the energy in the second pipe is released by friction?
d. What is the rate of change of the volume in the first tank?
e. What is the rate of change of the energy in the second tank?

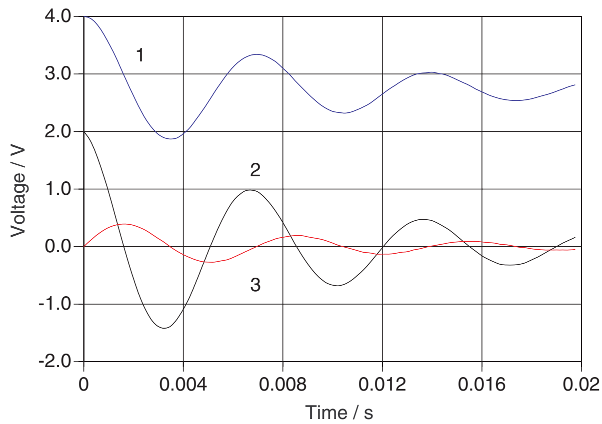
7. A solenoid is connected to an electrical circuit between two capacitors.



These capacitors have capacitances of 58 μF (C1) and 99 μF (C2), and initial voltages of 4.0 V (C1) and 2.0 V (C2). At the point in time $t = 0$ s the circuit is closed. The diagram shows the voltages across the two capacitors as a function of time.



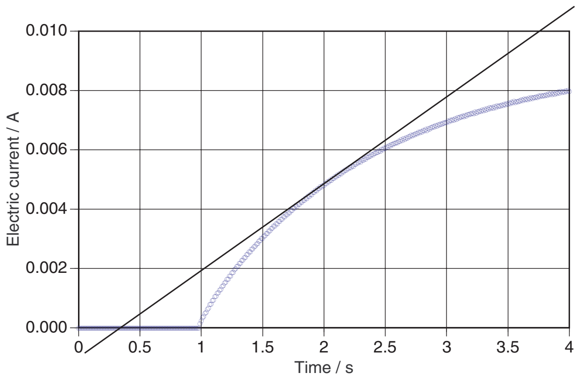
a. The capacitors in this electrical circuit are connected in series. Calculate the total capacitance of the two capacitors. (You should obtain a value of 36.6 μF.)
b. From the diagram on the accompanying page, determine the period of oscillation and using your answer, determine the solinoid's inductance. (You should obtain 33 mH as your answer.)
c. Use the data of the capacitor voltages to determine graphically the electrical current at the point t = 00875 s (when both voltages are the same). What is the energy of the solinoid's magnetic field at that moment?
d. There are three voltages represented in the second diagram below. Which of the three curves shows the inductive voltage? What are your reasons for believing this?



e. Why is it that from $t = 0$ s until the end of the first period the change of energy in the circuit (meaning the total energy of capacitors and solinoids) equals the change of energy of the two capacitors?

Solutions

1. The data in the graph show the rising electric current in an RL circuit. What is the rate of change of the current at 2.0 s?



❑ about 0.74 A/s
❑ about $2.4 \cdot 10^{-3}$ A/s
✔ about $3.0 \cdot 10^{-3}$ A/s
❑ about $-2.4 \cdot 10^{-3}$ A/s
❑ about $3.0 \cdot 10^{-3}$ A
❑ arctan(36.5°) A/s

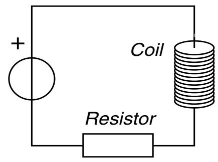
Explanation: dI_Q / dt = slope of tangent at t = 2 s.
Slope ≈ 0.010 A / 3.38 s = 0.0030 A/s.

2. Water is flowing out of a tank through a horizontal pipe fitted at the bottom. The pressure at the inlet and the outlet is measured. What does the difference of the pressure values represent at any moment?

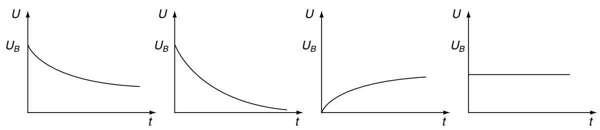
❑ The pressure difference because of resistance
❑ The pressure difference from the top to the bottom of the fluid in the tank
❑ The inductive pressure difference
✔ The sum of the resistive and the inductive pressure differences
❑ The pressure difference due to the narrowing of the flow from the tank to the pipe

Explanation: Two processes take place in the pipe: fluid friction (because of flow) and induction (because of change of flow). delta_P_pipe is responsible for both.

3. A coil made of a long thin copper wire is hooked up to a constant voltage battery and a resistor. The resistances of the resistor and the wire of the coil have similar values.



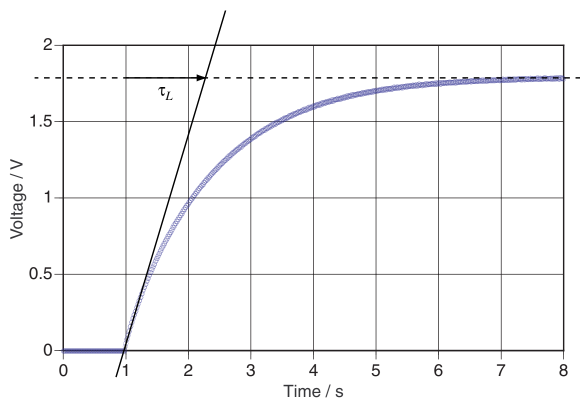
The circuit is closed at $t = 0$ s and the voltage across the coil is measured. Which of the diagrams represents the measurements best?



❑ ❑ ❑

Explanation: At t = 0 s, U_R = 0 V (since I_Q = 0 A), therefore U_coil = U_B. After a long time, dI_Q / dt = 0 and I_Q ≠ 0, therefore U_L = 0, but U_coil = U_R_coil = R_coil · I_Q ≠ 0!

4. A coil and a resistor are hooked up to a constant voltage battery. The inductance of the coil is 630 H. The voltage across the resistor is measured. The diagram shows the data taken during the experiment. What is the total resistance of all resistors in the circuit?



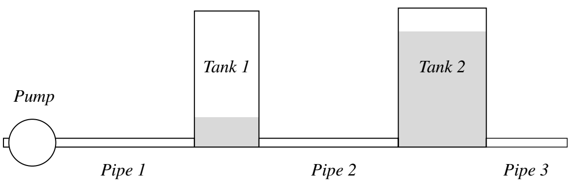
❑ close to 0 Ω
❑ about 2.1 μΩ
✔ about 500 Ω
❑ about 820 Ω
❑ larger than 820 Ω

Explanation: Inductive time constant tau_L = L / R. From the graph, tau_L ≈ 1.35 s. Therefore, R = L / tau_L ≈ 500 Ohm.

5. A 100 μF capacitor is charged to voltage of 10 V. Then it is hooked up to a resistor having a resistance of 100 Ω. The rate of change of the energy of the capacitor at the beginning is
   - ✔ – 1.0 J/s
   - ❑ – 1.0 W/s
   - ❑ 1.0 W
   - ❑ – 10 W
   - ❑ 0.10 J/s

   Explanation: dW / dt = I_W, I_W = U·I_Q. At t = 0 s, I_Q = U_R / R = U_C / R = 10 / 100 A = 0.10 A. Therefore, I_W = – 10·0.10 W = – 1.0 W.

6. An oil tank with a cross section of 1.0 m^2 is filled by a pump through a long horizontal pipe. The tank is connected by another horizontal pipe to a second one with a cross section of 5.0 m^2. This second container has a pipe which leads out into the environment. Initially, the oil levels are 1.0 m and 8.0 m. The flow resistance of the three pipes are $1.0 \cdot 10^6$ Pa·s/m^3, $1.0 \cdot 10^6$ Pa·s/m^3 and $0.5 \cdot 10^6$ Pa·s/m^3. The pump works with a constant pressure difference of 1.0 bar. Assume the density of the oil to be 1000 kg/m^3, and take g = 10 N/kg. Set the ambient air pressure to zero.



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SOLUTION

a. IV1 = delta_pR1 / R1 = $(1 \cdot 10^5 – 1000 \cdot 10 \cdot 1) / 1.0 \cdot 10^6 = 9.0 \cdot 10^{-2}$ m^3/s

IV2 = delta_pR2 / R2 = $(1000 \cdot 10 \cdot 1 – 1000 \cdot 10 \cdot 8) / 1.0 \cdot 10^6 = – 7.0 \cdot 10^{-2}$ m^3/s

IV3 = delta_pR3 / R3 = $(1000 \cdot 10 \cdot 8 – 0) / 0.5 \cdot 10^6 = – 16.0 \cdot 10^{-2}$ m^3/s

b. P_pump = delta_p_pump · IV1 = $1 \cdot 10^5 \cdot 9.0 \cdot 10^{-2}$ = 9000 W

c. P_R2 = delta_pR2 · IV2 = 4900 W

d. dV1/dt = IV1 – IV2 = $9.0 \cdot 10^{-2}$ m^3/s – (– $7.0 \cdot 10^{-2}$ m^3/s) = $16.0 \cdot 10^{-2}$ m^3/s

e. dW2/dt = – (|IV2| + |IV3|)·delta_pC2 = – $23.0 \cdot 10^{-2}$ m^3/s · 1000·10·8 Pa = –– 1840 W.

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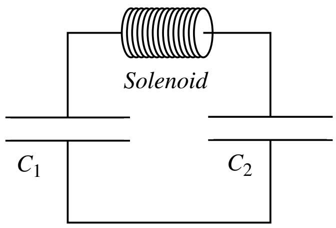

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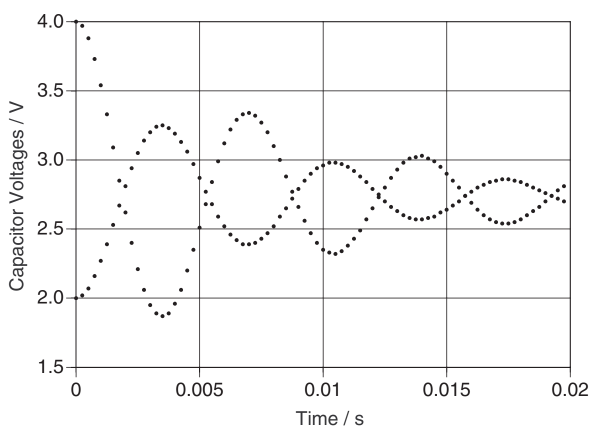

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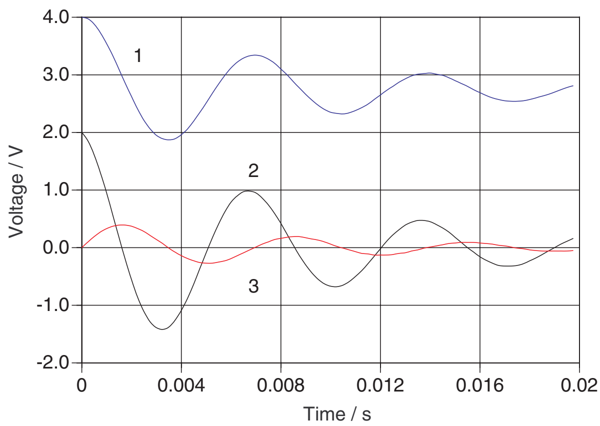

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