PHYSICS EXAM

1. Oil having a density of 900 kg/m^3 is pumped through a horizontal pipe into a straight walled tank. The hydraulic resistance for the flow is 10^8 Pa·s/m^3. At a moment when the fluid level in the tank is 5.0 m, the volume current is $1.0 \cdot 10^{-3}$ m^3/s. What is the rate of change of the energy stored in the tank?
   - ❑ 1.44 W
   - ❑ 0.44 W
   - ❑ 100 W
   - ❑ 44 W
   - ❑ 144 W
   - ❑ 1.0 W

   Explanation:...
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2. A solenoid (coil) having an inductance of 600 H and a resistance of 300 Ω is hooked up to a battery setting up a constant voltage of 5.0 V. Then the circuit is closed. What will the final value of the electric current be?
   - ❑ 0 A
   - ❑ 2.0 A
   - ❑ $1.67 \cdot 10^{-2}$ A
   - ❑ 0.5 A
   - ❑ 120 A
   - ❑ 60 A

   Explanation:...
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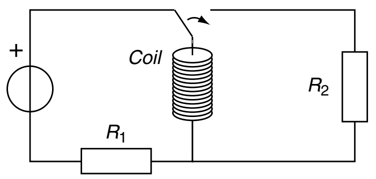
3. An electric current of 20 mA is flowing through a solenoid (coil) having an inductance of 600 H and a resistance of 300 Ω. Now it is suddenly connected to another part of the circuit having a resistor with a resistance of 300 Ω. How long will it take for the current to go down to half of its initial value?



   - ❑ 0.7 s
   - ❑ Infinitely long
   - ❑ 1.0 s
   - ❑ $3.6 \cdot 10^5$ s
   - ❑ 1.4 s

   Explanation:...
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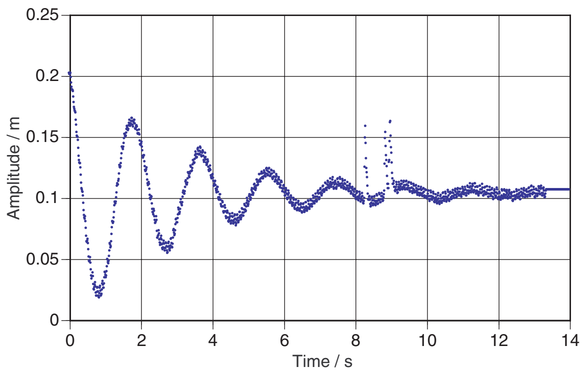
4. The diagram shows the data taken of an oscillatory process. What is the period of oscillation?



   - ❑ about 0.8 s
   - ❑ about 1.7 s
   - ❑ about 1.9 s
   - ❑ about 13 s
   - ❑ longer than 13 s

   Explanation:...
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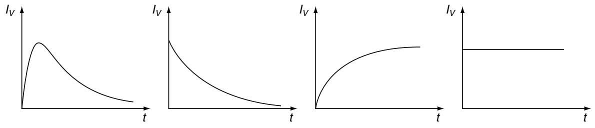
5. Water is flowing out of a tank through a horizontal pipe fitted at the bottom. There is a plug at the end of the pipe which is removed at $t = 0$ s. The flow is best represented by



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Explanation:..
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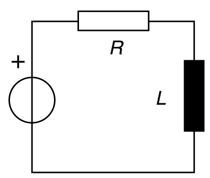
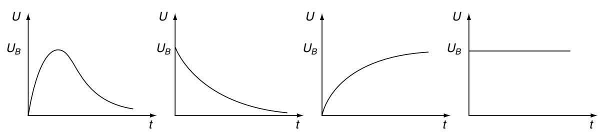
6. A resistor and an ideal inductor (without any resistance) are hooked up to a constant voltage battery.



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



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Explanation:..
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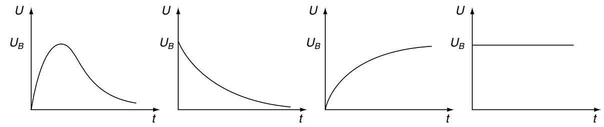
7. A coil made of a long thin copper wire is hooked up to a constant voltage battery. The circuit is closed at $t = 0$ s and the voltage across the coil is measured. Which of the diagrams represents the measurements best?



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Explanation:..
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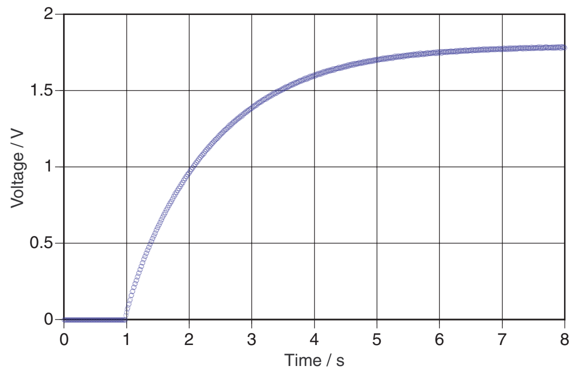
8. A coil and a resistor are hooked up to a constant voltage battery. The voltage across the resistor is measured. The diagram shows the data taken during the experiment. What is the inductive time constant?



❏ about 0.7 s
❏ about 1.3 s
❏ about 3 s
❏ about 8 s
❏ longer than 8 s

Explanation:..
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9. Water leaves a large open tank through a pipe at the bottom. The level of the water in the tank is 4.0 m, and the volume current of the water is 5 l/s. The radius of the pipe is 5.0 cm. What is the energy current associated with the flow of water leaving the tank?

- ❏ 200 J/s
- ❏ 700 W
- ❏ 700 W/s
- ❏ 200 W/s
- ❏ 7 W/s
- ❏ 2 W

Explanation:...
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10. A 20 mF capacitor is discharged from a voltage of 20 V to a voltage of 10 V. The change of the energy of the capacitor is

- ❏ 4 J
- ❏ 3.0 mJ
- ❏ – 200 mJ
- ❏ – 100 mJ
- ❏ 3.0 W·s
- ❏ – 3.0 W·s

Explanation:...
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SOLUTIONS

1. Oil having a density of 900 kg/m^3 is pumped through a horizontal pipe into a straight walled tank. The hydraulic resistance for the flow is 10^8 Pa·s/m^3. At a moment when the fluid level in the tank is 5.0 m, the volume current is $1.0 \cdot 10^{-3}$ m^3/s. What is the rate of change of the energy stored in the tank?

- ❏ 1.44 W
- ❏ 0.44 W
- ❏ 100 W
- ✔ 44 W
- ❏ 144 W
- ❏ 1.0 W

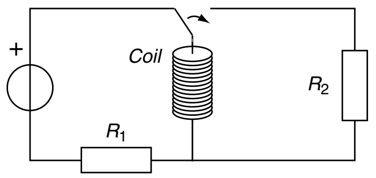
Explanation: The rate of change of the energy stored in the container equals the power of the pump minus the power of the flow resistance in the pipe, i.e., delta_Pp·I_V – delta_PR·I_V. Since delta_Pp – delta_PR = delta_Pc we have dW_container/dt = delta_Pc·I_V = rho·g·h·I_V = $900 \cdot 9.81 \cdot 5.0 \cdot 1.0 \cdot 10^{-3}$ W = 44 W. (We do not need to know the flow resistance or the loss of power in the pipe!)

2. A solenoid (coil) having an inductance of 600 H and a resistance of 300 Ω is hooked up to a battery setting up a constant voltage of 5.0 V. Then the circuit is closed. What will the final value of the electric current be?

- ❏ 0 A
- ❏ 2.0 A
- ✔ $1.67 \cdot 10^{-2}$ A
- ❏ 0.5 A
- ❏ 120 A
- ❏ 60 A

Explanation: The abstract circuit consists of a constant voltage battery, a pure inductive element and a pure resistive element. A the end, the current does not change any longer, so the inductive voltage becomes zero. Therefore the final voltage across the resisitive element is equal to the voltage of the battery. Therefore we have I_Q = U_R / R = U_B / R = 5/300 A

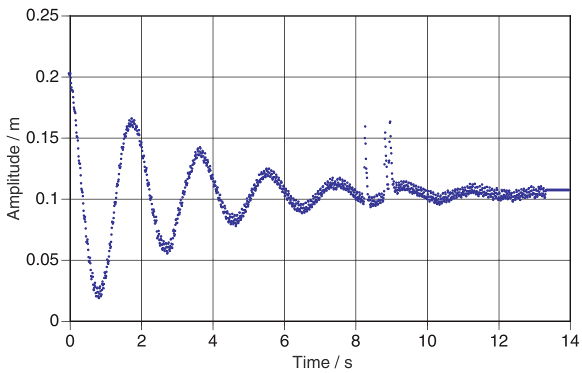
3. An electric current of 20 mA is flowing through a solenoid (coil) having an inductance of 600 H and a resistance of 300 Ω. Now it is suddenly connected to another part of the circuit having a resistor with a resistance of 300 Ω. How long will it take for the current to go down to half of its initial value?



- ✔ 0.7 s
- ❏ Infinitely long
- ❏ 1.0 s
- ❏ $3.6 \cdot 10^5$ s
- ❏ 1.4 s

Explanation: The current in the second circuit will decrfease exponentially. The inductive time constant of this process is L / R = L / (R_L + R_ext) = 600 / 600 s = 1.0 s. In 1.0 s, the current decreases to 36% of its initial value. It takes 0.7 s for the current to decrease to half of its initial value.

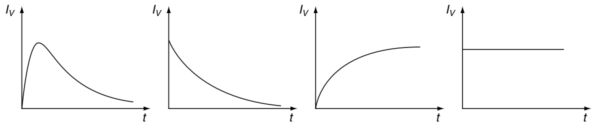
4. The diagram shows the data taken of an oscillatory process. What is the period of oscillation?



- ❏ about 0.8 s
- ❏ about 1.7 s
- ✔ about 1.9 s
- ❏ about 13 s
- ❏ longer than 13 s

Explanation: Oscillatory period = distance between two maxima (or minima, or equilibrium points). Note that t = 0 is NOT a maximum!

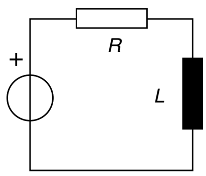
5. Water is flowing out of a tank through a horizontal pipe fitted at the bottom. There is a plug at the end of the pipe which is removed at $t = 0$ s. The flow is best represented by



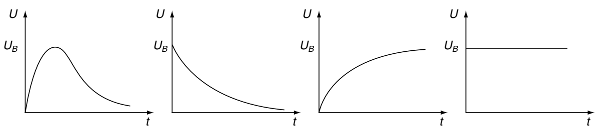
✔ ❑ ❑ ❑

Explanation: The current starts at zero, then increases to its maximum in a relatively short time. After that it decreases according to its capacitive time constant (tau_c = R_V·K_V).

6. A resistor and an ideal inductor (without any resistance) are hooked up to a constant voltage battery.



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



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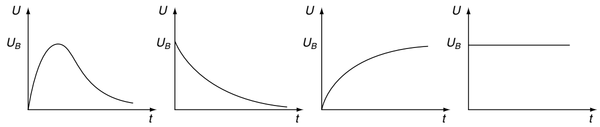
Explanation: The voltage across an ideal inductor depends only upon the rate of change of the current. This rate of change is largest at the beginning and becomes zero toward the end.

7. A coil made of a long thin copper wire is hooked up to a constant voltage battery. The circuit is closed at $t = 0$ s and the voltage across the coil is measured. Which of the diagrams represents the measurements best?



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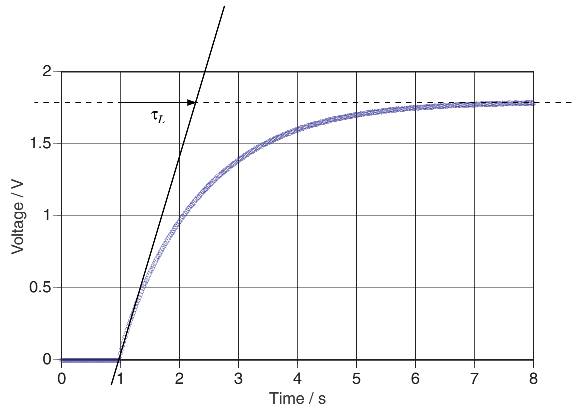
Explanation: The real voltage measured across the coil can be thought of as the sum of the voltages of its resistive and inductive elements. This sum is equal to the only other voltage in the curcuit (the constant voltage of the battery).

8. A coil and a resistor are hooked up to a constant voltage battery. The voltage across the resistor is measured. The diagram shows the data taken during the experiment. What is the inductive time constant?



❑ about 0.7 s
✔ about 1.3 s
❑ about 3 s
❑ about 8 s
❑ longer than 8 s

Explanation: Time from beginning of rise of current to the intersection of the initial tangent and the horizontal line representing the final value of the current.

9. Water leaves a large open tank through a pipe at the bottom. The level of the water in the tank is 4.0 m, and the volume current of the water is 5 l/s. The radius of the pipe is 5.0 cm. What is the energy current associated with the flow of water leaving the tank?
   - ❑ 200 J/s
   - ❑ 700 W
   - ✔ 700 W/s
   - ❑ 200 W/s
   - ❑ 7 W/s
   - ❑ 2 W

   Explanation: The energy current leaving the tank equals the pressure of the fluid leaving the tank multiplied by the volume flux of this current. The pressure of the fluid at the entrance to the pipe is P_a + rho·g·h (where P_a is the ambient pressure). Therefore we have I_W = (P_a + rho·g·h)·I_V = (1.0·105 + 1000·10·4.0)·5.0·10–3 W = 1.4·105 · 5.0·10–3 W = 700 W.

10. A 20 mF capacitor is discharged from a voltage of 20 V to a voltage of 10 V. The change of the energy of the capacitor is
   - ❑ 4 J
   - ❑ 3.0 mJ
   - ❑ – 200 mJ
   - ❑ – 100 mJ
   - ❑ 3.0 W·s
   - ✔ – 3.0 W·s

   Explanation: $W = 0.5 \cdot C \cdot U^2$, therefore $\Delta W = 0.5 \cdot C \cdot (U2^2 - U1^2) = 0.5 \cdot 20 \cdot 10^{-3} \cdot (10^2 - 20^2)$ J = – 3.0 J