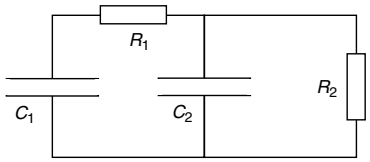
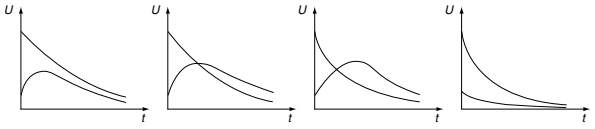
PHYSICS EXAM

1. Two capacitors are connected in a circuit as shown in the figure. The values of R_1 and R_2 are of similar magnitude, and so are C_1 and C_2. At the beginning the capacitors are charged to voltages of 2 V (C_1) and 5 V (C_2) respectively. Which of the following diagrams represents the actual measurements of the voltages best?





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Explanation:.....
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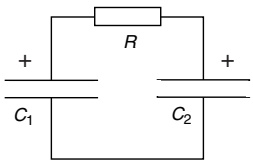
2. Two capacitors and a resistor are connected in a circuit as in the figure. The capacitance of the first capacitor is 100 μF, that of the second is 200 μF. At the beginning the voltage across each of the capacitors is 5.0 V. The resistance is 20 kΩ.



At the beginning, the current of electric charge through the resistor is

❑ initial electric current = $2.5 \cdot 10^{-4}$ A
❑ initial electric current = $1.25 \cdot 10^{-4}$ A
❑ initial electric current = $5.0 \cdot 10^{-9}$ A
❑ initial electric current = 0 C/s

Explanation:.....
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3. Water flows out of a large tank through a pipe at the bottom having a radius of 5.0 cm. At a particular moment the volume current of the water flowing out is 0.0393 m^3/s. At the same time the water level above the pipe is 6.5 m. The pressure difference due to the flow through the pipe (measured *in the direction of the flow*) therefore is

❑ – 51.25 kPa
❑ 12.5 kPa
❑ – 63750 Pa
❑ – 5.125 bar
❑ 51.25 kPa

Explanation:.....
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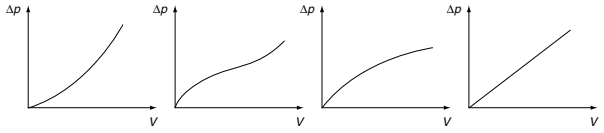
4. Consider a spherical water tank. The pressure difference – volume diagram which best fits this tank is



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Explanation:.....
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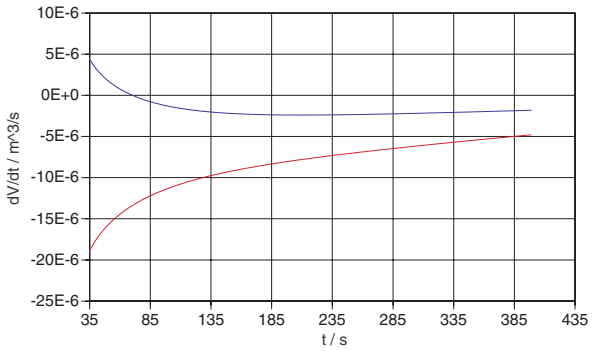
5. The diagram shows the rate of change of volume in two containers. The lower curve is for the second container whose initial volume at t = 35 s is $4.0 \cdot 10^{-3}$ m^3.



After 100 s (at t = 135 s), the volume in tank 2 is

- ❑ 2.72 liters
- ❑ 5.28 liters
- ❑ 3.72 liters
- ❑ $27.2 \cdot 10^{-3}$ m^3
- ❑ $5.28 \cdot 10^{-3}$ m^3

Explanation:.....
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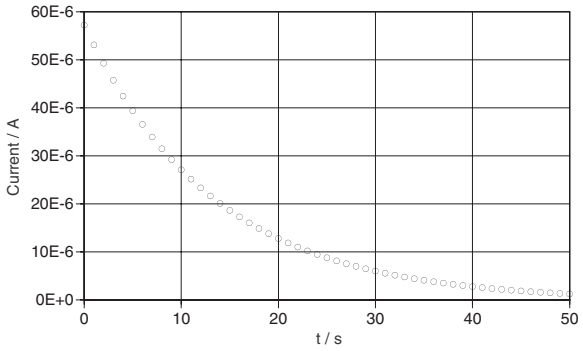
6. The diagram shows an electric current as a function of time. How much electric charge has been transported by this current in the time span from 10 s to 30 s?



- ❑ 0.69 mA·s
- ❑ – 0.69 mA·s
- ❑ 280 A·s
- ❑ – 0.28 mA·s
- ❑ 0.28 mA·s

Explanation:.....
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7. A single resistor having a resistance of 10 kΩ is hooked up to a battery. A voltmeter with an internal resistance of 1 MΩ is used to measure the voltage across the resistor. By how much does the voltmeter change the current through the circuit.

- ❑ Not at all
- ❑ By – 1%
- ❑ By – 0.1%
- ❑ By 1%
- ❑ By 0.1%

Explanation:.....
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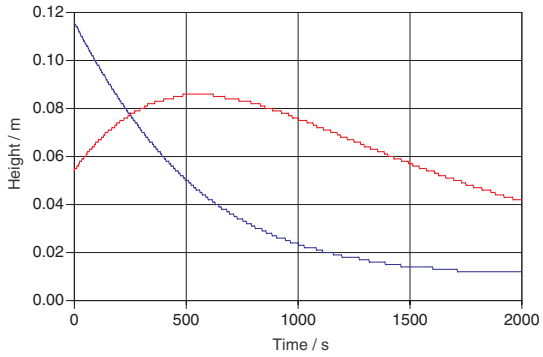
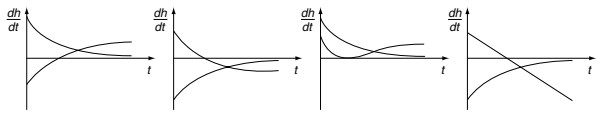
8. The diagram shows the water levels in two tanks as a function of time.



Which of the following graphs comes closest to the graph of the rate of change of the two levels?



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Explanation:.....
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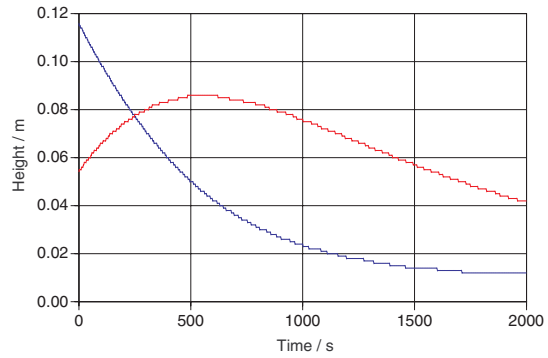
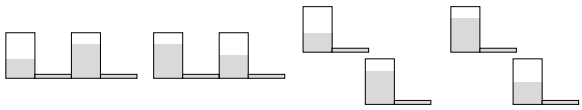


Which of the following experimental setups—with initial fluid levels shown—yields such behavior?



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Explanation:.....
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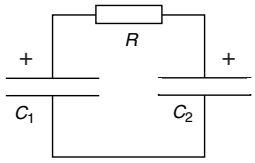
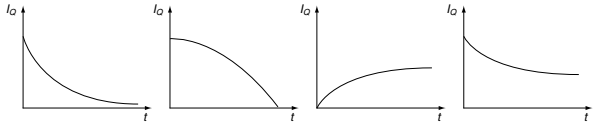
10. Two capacitors and a resistor are connected in a circuit as in the figure. The electric current through the resistor is measured.



Which of the following graphs is the best representation of the electric current?



❑ ❑ ❑ ❑

Explanation:.....
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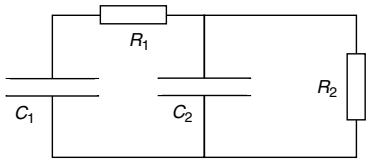
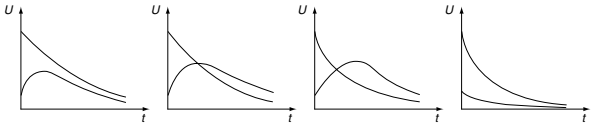
SOLUTIONS

1. Two capacitors are connected in a circuit as shown in the figure. The values of R_1 and R_2 are of similar magnitude, and so are C_1 and C_2. At the beginning the capacitors are charged to voltages of 2 V (C_1) and 5 V (C_2) respectively. Which of the following diagrams represents the actual measurements of the voltages best?

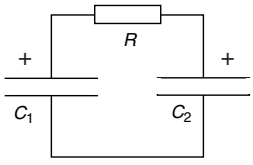




❑ ✔ ❑ ❑

Explanation: U1 must become larger than U2 at one point for discharging to continue. The maximum of U1 must occur when U1 = U2.

2. Two capacitors and a resistor are connected in a circuit as in the figure. The first capacitance is 100 µF, the second is 200 µF. At the beginning the voltage across each of the capacitors is 5.0 V. The resistance is 20 kΩ.



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❑ initial electric current = $1.25 \cdot 10^{-4}$ A
❑ initial electric current = $5.0 \cdot 10^{-9}$ A
✔ initial electric current = 0 C/s

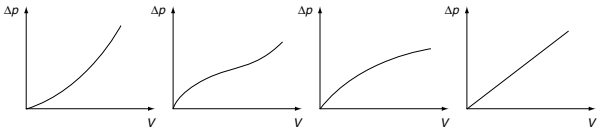
Explanation: The "levels" of the two capacitors are equal right from the beginning (the capacitors are in equilibrium already). Therefore there is no flow of electric charge.

3. Water flows out of a large tank through a pipe at the bottom having a radius of 5.0 cm. At a particular moment the volume current of the water flowing out is 0.0393 m^3/s. At the same time the water level above the pipe is 6.5 m. The pressure difference due to the flow through the pipe (measured *in the direction of the flow*) therefore is

✔ – 51.25 kPa
❑ 12.5 kPa
❑ – 63750 Pa
❑ – 5.125 bar
❑ 51.25 kPa

Explanation: The sum of all pressure differences is a closed circuit must be zero. Therefore: $\Delta p_R = -\Delta p_C - \Delta p_{Bernoulli}$
$v = I_V / A = 0.0393 / (\pi \cdot 0.050^2)$ m/s = 5.0 m/s
$\Delta p_R = -\rho g h - (-0.5 \rho v^2) = -1000 \cdot 9.81 \cdot 6.5$ Pa + $0.5 \cdot 1000 \cdot 5.0^2$ Pa = $-5.125 \cdot 10^4$ Pa = – 51.25 kPa

4. Consider a spherical water tank. The pressure difference – volume diagram which best fits this tank is



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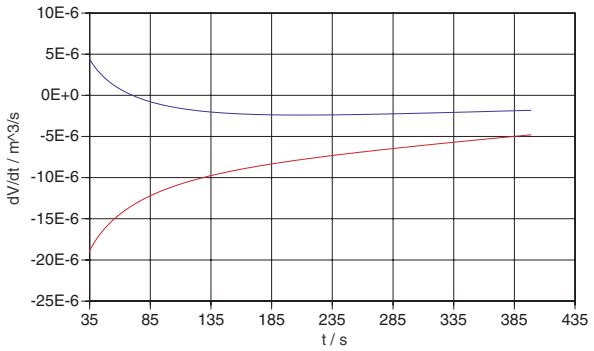
Explanation: First, the cross section of the tank increases (counting upward from the bottom) which means that the slope of the Δp–V characteristic must decrease. Then the cross section decreases (slope of characteristic curve must increase).

5. The diagram shows the rate of change of volume in two containers. The lower curve is for the second container whose initial volume at t = 35 s is $4.0 \cdot 10^{-3}$ m^3.



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✔ 2.72 liters
❑ 5.28 liters
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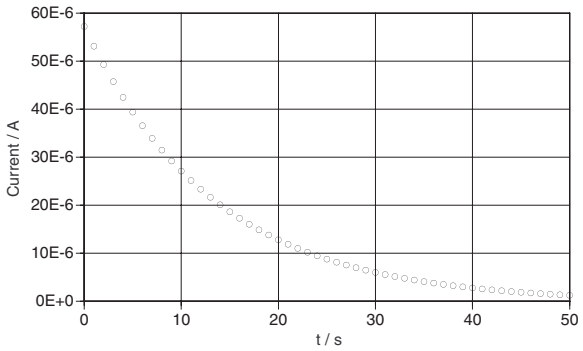
Explanation: Add the change of volume to the initial volume. Change of volume is obtained from area between curve 2 and the t-axis:
$V_{t=123} = V_{t=35} + \Delta V \approx 4.0 \cdot 10^{-3}$ m^3 + ($-$ 1.35$\cdot 10^{-3}$ m^3) = $2.65 \cdot 10^{-3}$ m^3

6. The diagram shows an electric current as a function of time. How much electric charge has been transported by this current in the time span from 10 s to 30 s?



❑ 0.69 mA·s
❑ – 0.69 mA·s
❑ 280 A·s
❑ – 0.28 mA·s
✔ 0.28 mA·s

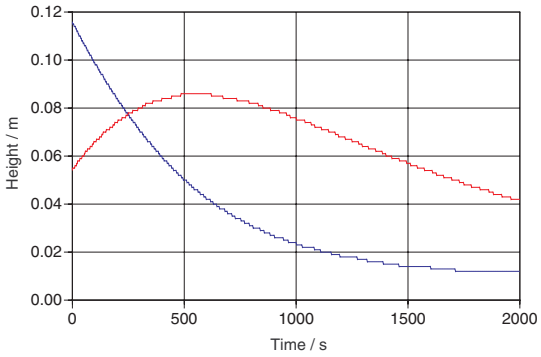
Explanation: Transported charge from area between curve and t-axis: $Q_e \approx 2.75 \cdot 10^{-4}$ A·s

7. A single resistor having a resistance of 10 kΩ is hooked up to a battery. A voltmeter with an internal resistance of 1 MΩ is used to measure the voltage across the resistor. By how much does the voltmeter change the current through the circuit.

❑ Not at all
❑ By – 1%
❑ By – 0.1%
✔ By 1%
❑ By 0.1%

Explanation: With second resistor parallel to the first, the resistance in the circuit is reduced. Therefore the current will increase. Since $R_V = 100 \cdot R$, the total resistance is 1% smaller than R. Therefore, the current increases by 1%.

8. The diagram shows the water levels in two tanks as a function of time.



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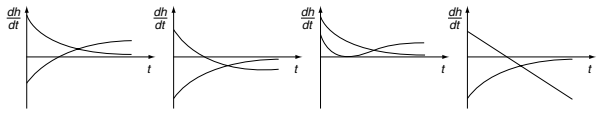
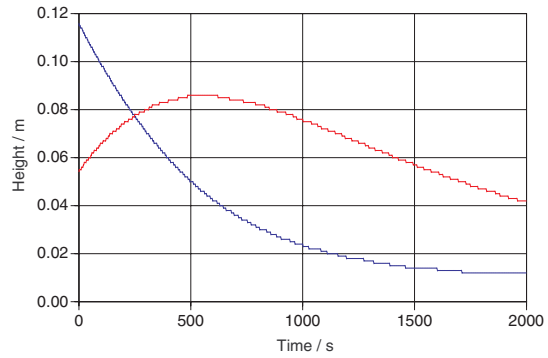


❑ ✔ ❑ ❑

Explanation: Rate of change of curve 1 is negative for all t. Rate of change of curve 2 is positive at first, then negative (with an almost constant negative value for large t).

9. The diagram shows the water levels in two tanks as a function of time.



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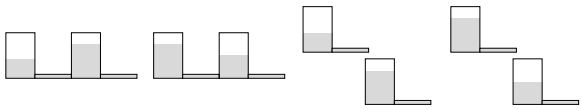

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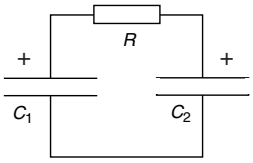
Explanation: (Curve 2 is the one with the maximum.) Maximum of curve 2 is not where h1 = h2, therefore the tanks must be separate (last two possibilities). The level in the upper tank can only decrease (as in curve 1), therefore it must be the tank with the higher initial level of fluid.

10. Two capacitors and a resistor are connected in a circuit as in the figure. The electric current through the resistor is measured.



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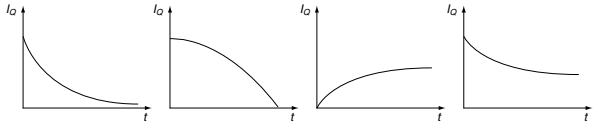

✔ ❑ ❑ ❑

Explanation: The flow is largest at the beginning and changes the fastest. At the end, the capacitors will be in equilibrium and therefore the current must go to zero.