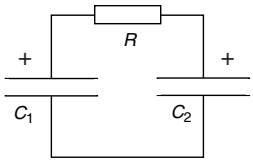
PHYSICS EXAM

1. The rate of change of volume of water of a lake is –12 m^3/s. The rivers flowing in and out carry water flows of 45 m^3/s (in) and 60 m^3/s (out). Which answer is correct? (There is only one correct answer.)

   ❏ There is no other process
   ❏ It rains into the lake with a rate of 3 m^3/s
   ❏ Water evaporates at a rate of 3 m^3/s
   ❏ There is an additional inflow of 15 m^3/s

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

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. The voltage across the first capacitor is 5.0 V. After the equilibration in the circuit, a voltage of 0 V is measured across each of the capacitors. Which answer is correct? (There is only one correct answer.)



   ❏ The initial voltage across C2 was 5 V
   ❏ The initial voltage across C2 was – 5 V
   ❏ The initial voltage across C2 was – 10 V
   ❏ The initial charge of C2 was – 500 µA·s
   ❏ The initial charge of C2 was – 250 µA·s

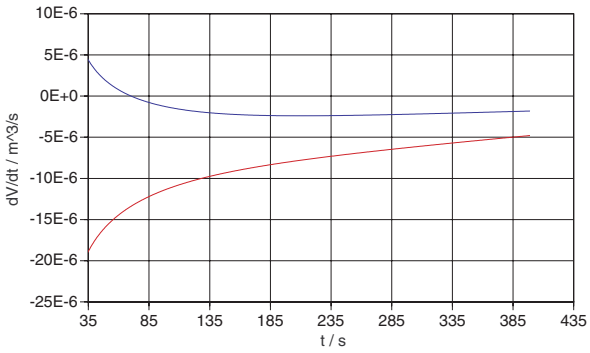
   Explanation:.....
   .....
   .....
   .....

3. A single resistor having a resistance of 10 Ω is hooked up to a battery. An ameter with an internal resistance of 0.1 Ω is used to measure the electric current through the resistor. By how much does the ameter change the current through the circuit?

   ❏ Not at all
   ❏ By – 1%
   ❏ By – 0.1%
   ❏ By 1%
   ❏ By 0.1%

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

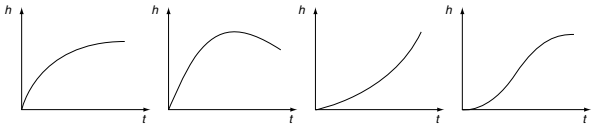
4. The diagram shows the rate of change of volume in two containers. The upper curve is for the first container. When is the volume of fluid in the first container the same again as at the beginning (i.e., at t = 35 s)?



   ❏ Never
   ❏ at 70 s
   ❏ at 85 s
   ❏ at 125 s
   ❏ at 235 s

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

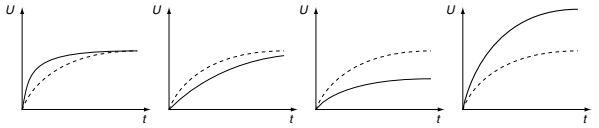
5. An oil tank is filled through a straight horizontal pipe fitted at the bottom. The pump used to fill the tank sets up a constant pressure difference during filling. Which of the following diagrams represents the process most accurately?



❑ ❑ ❑ ❑

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

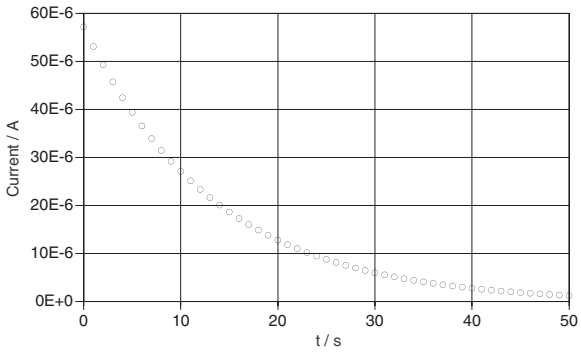
6. A capacitor is hooked up to a battery and a resistor. In the following graphs, the dashed lines show the voltage across the capacitor during charging. Now the resistance of the resistor is doubled. Which of the following *solid* curves most closely resembles the new charging curve?



❑ ❑ ❑ ❑

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

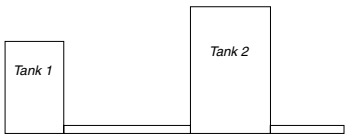
7. The diagram shows an electric current through a resistor having a resistance of 100 kΩ as a function of time. Measured in the *opposite* direction to the direction of flow of charge, what is the voltage across the resistor at $t = 15$ s?

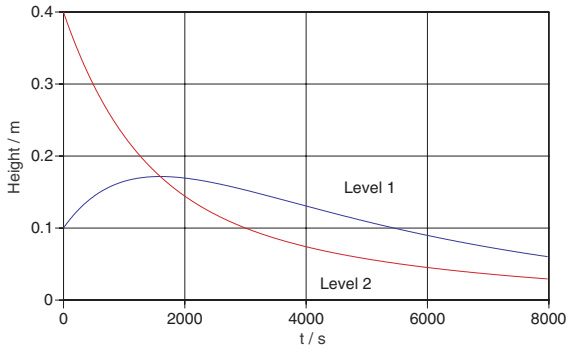


❑ 1.88 V
❑ 1.88 kV
❑ – 5.32 kV
❑ $-1.88 \cdot 10^{-10}$ V
❑ – 1.88 V

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

8. Two tanks are connected by pipes as shown. A fluid exhibits laminar flow, and the corresponding levels are represented in the accompanying graph.



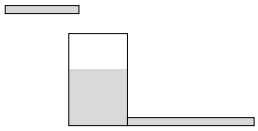


When the level in tank 2 has fallen to *a quarter* of its initial value, what is the absolute value of the flow through the pipe *connecting* the two tanks compared to the *initial flow* through this pipe?

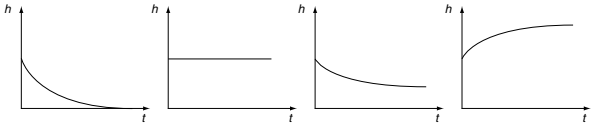
- ❏ About half the initial value
- ❏ Zero
- ❏ About 20%
- ❏ About 70%
- ❏ About twice as much

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

9. An oil tank drains through a straight horizontal pipe at the bottom. At the same time oil flows into the container at the top at a constant rate.



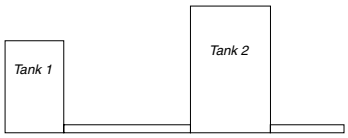
Which of the following graphs *cannot* be correct?



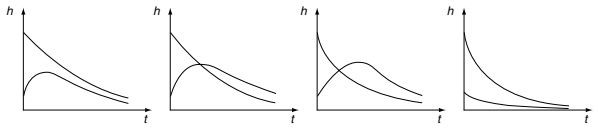
❏ ❏ ❏ ❏

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

10. Two tanks are connected by pipes as shown. The pipes have the same diameter, but the second pipe is only *half as long*. At the beginning, the water level in Tank 1 is about four times higher than in Tank 2. The flows are laminar.



Which of the following graphs is the best representation of the water levels?



❏ ❏ ❏ ❏

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

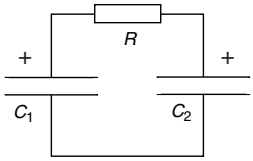
SOLUTIONS

1. The rate of change of volume of water of a lake is –12 m^3/s. The rivers flowing in and out carry water flows of 45 m^3/s (in) and 60 m^3/s (out). Which answer is correct? (There is only one correct answer.)

   ❏ There is no other process
   ✔ It rains into the lake at a rate of 3 m^3/s
   ❏ Water evaporates at a rate of 3 m^3/s
   ❏ There is an additional inflow of 15 m^3/s

   Explanation: There must be an additional input at the rate of 3 m^3/s. Balance of volume: dV/dt = IV1 + IV2 + IV3, therefore IV3 = dV/dt – IV1 – IV2 = – 12 m^3/s – (+ 45 m^3/s) – (–60 m^3/s) = + 3 m^3/s.

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. The voltage across the first capacitor is 5.0 V. After the equilibration in the circuit, a voltage of 0 V is measured across each of the capacitors. Which answer is correct? (There is only one correct answer.)



   ❏ The initial voltage across C2 was 5 V
   ❏ The initial voltage across C2 was – 5 V
   ❏ The initial voltage across C2 was – 10 V
   ✔ The initial charge of C2 was – 500 µA·s
   ❏ The initial charge of C2 was – 250 µA·s

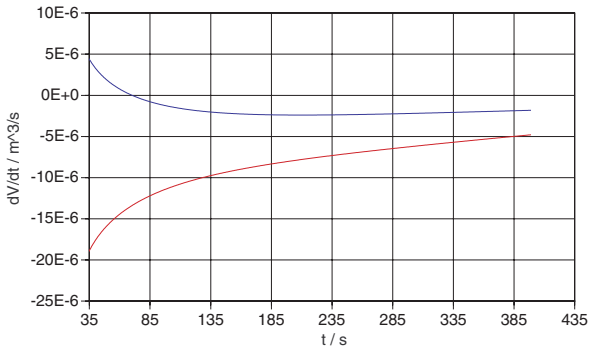
   Explanation: To obtain a final voltage of 0 V, the initial voltage of C2 must have been – 2.5 V. Conservation of charge: ΔQ1 = – ΔQ2. Since the charge of each capacitor is zero at the end, we have $Q_{2,initial} = - Q_{1,initial}$, $O_{1,initial} = C_1 \cdot U_{1,initial}$ = 100µF·5V = 500 µF.

3. A single resistor having a resistance of 10 Ω is hooked up to a battery. An ameter with an internal resistance of 0.1 Ω is used to measure the electric current through the resistor. By how much does the ameter change the current through the circuit?

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

   Explanation: With the ameter in series with the resistor, the resistance of the circuit increases by 1%. This lets the current decrease by 1%.

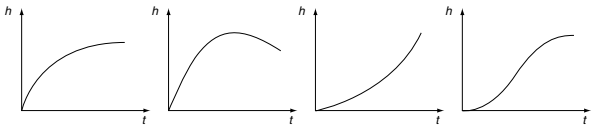
4. The diagram shows the rate of change of volume in two containers. The upper curve is for the first container. When is the volume of fluid in the first container the same again as at the beginning (i.e., at t = 35 s)?



   ❏ Never
   ❏ at 70 s
   ❏ at 85 s
   ✔ at 125 s
   ❏ at 235 s

   Explanation: The area between curve 1 and the time axis represents the change of volume in tank 1. The change of volume is first positive (the volume increases until about 70 s), then it is negative (the volume decreases again). At about t = 125 s, the change of content has become zero.

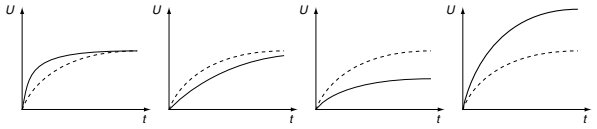
5. An oil tank is filled through a straight horizontal pipe fitted at the bottom. The pump used to fill the tank sets up a constant pressure difference during filling. Which of the following diagrams represents the process most accurately?



✔ ❑ ❑ ❑

Explanation: The pressure difference set up by the pump equals the sum of the pressure differences across the pipe (because of friction) and the pressure difference across the fluid column in the tank. Therefore, the current is largest at the beginning, and it becomes zero when the pressure difference across the fluid column has become equal to the pressure difference of the pump.

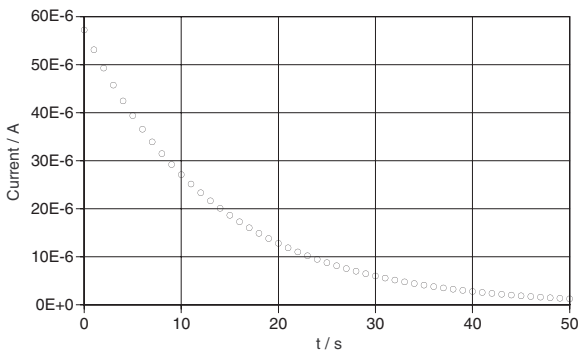
6. A capacitor is hooked up to a battery and a resistor. In the following graphs, the dashed lines show the voltage across the capacitor during charging. Now the resistance of the resistor is doubled. Which of the following *solid* curves most closely resembles the new charging curve?



❑ ✔ ❑ ❑

Explanation: With a resistance which is double the one of the first experiment, the charging takes twice as long (but it goes to the same final level).

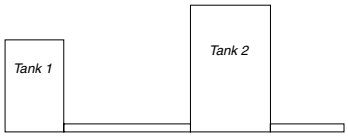
7. The diagram shows an electric current through a resistor having a resistance of 100 kΩ as a function of time. Measured in the *opposite* direction to the direction of flow of charge, what is the voltage across the resistor at $t = 15$ s?

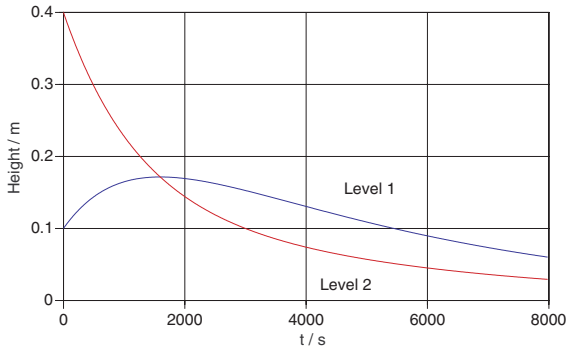


❑ 1.88 V
❑ 1.88 kV
❑ – 5.32 kV
❑ $-1.88 \cdot 10^{-10}$ V
✔ – 1.88 V

Explanation: At 15 s, the electric current is about 18.8 µA. Therefore, UR = R·IQ = 10^5 W · $18.8 \cdot 10^{-6}$ A = 1.88 V. Measured against the flow of charge, we have a negative voltage.

8. Two tanks are connected by pipes as shown. A fluid exhibits laminar flow, and the corresponding levels are represented in the accompanying graph.



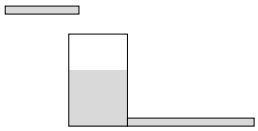


When the level in tank 2 has fallen to *a quarter* of its initial value, what is the absolute value of the flow through the pipe *connecting* the two tanks compared to the *initial flow* through this pipe?

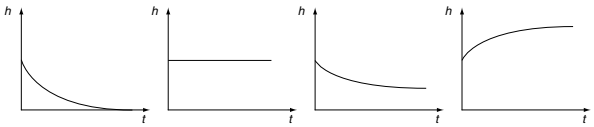
❑ About half the initial value
❑ Zero
✔ About 20%
❑ About 70%
❑ About twice as much

Explanation: In laminar flow, the current is proportional to the pressure difference across the pipe. The pressure difference across the connecting pipe is proportional to the level difference. At the beginning this level difference is 30 cm. When the level in tank 2 has become a quarter of its initial value, the level difference in the two tanks is about 5 to 6 cm.

9. An oil tank drains through a straight horizontal pipe at the bottom. At the same time oil flows into the container at the top at a constant rate.



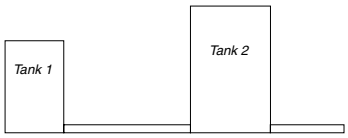
Which of the following graphs *cannot* be correct?



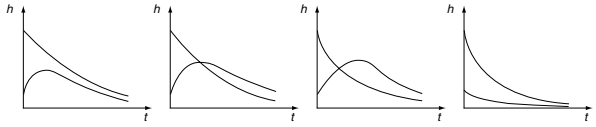
✔ ❑ ❑ ❑

Explanation: With a constant inflow, the level in the tank must reach a constant final value; it cannot go to zero. (Depending on the magnitude of the inflow, the level first goes up, or down, or it stays constant from the beginning.)

10. Two tanks are connected by pipes as shown. The pipes have the same diameter, but the second pipe is only *half as long*. At the beginning, the water level in Tank 1 is about four times higher than in Tank 2. The flows are laminar.



Which of the following graphs is the best representation of the water levels?



✔ ❑ ❑ ❑

Explanation: The level in tank 2 must always remain smaller than the one in tank 1. With twice the length of the pipe between the two tanks, but four times the initial heigth (giving a height difference which is three times as large as the height in tank 2), the out flow of tank 2 is smaller than the inflow. Therefore the level in tank 2 must rise at the beginning.