

The 34th International Science Olympiad for Young Mathematicians, Physicists and Chemists November 30, 2021 Physics – Form 10

1. A race car driver races around a circular track of length L = 1000 m. He starts from rest and accelerates uniformly with acceleration $a_1 = 8 \text{ m/s}^2$, then reaches its top speed and continues to make laps around the track, until eventually decelerating with rate $a_2 = 11 \text{ m/s}^2$. The first lap takes the driver $t_1 = 21.4$ s.

- a) What's the car's top speed? (6 points.)
- b) How much time does the driver's fastest lap take? (2 points.)
- c) How much time does the driver's last lap take? (2 points.)

2. A calorimeter has M = 1 kg of water in it at $T_1 = 20 \text{ °C}$. A hot aluminium bar is dropped into the calorimeter. As a result, after the thermal equilibrium has been reached, the water temperature becomes $T_2 = 52 \text{ °C}$. Subsequently, another identical aluminium bar is dropped into the calorimeter and the new equilibrium temperature is $T_3 = 80 \text{ °C}$. Specific heat of water is $c_w = 4.2 \text{ kJ/K}$ and of aluminium, $c_a = 0.91 \text{ kJ/K}$.

- a) How much did the aluminium bars weigh? (8 points.)
- b) How hot were the aluminium bars before being dropped into the calorimeter? (2 points.)

3. An U-shaped pipe of height H = 30 cm and cross-section $S = 12 \text{ cm}^2$ is filled with water such that the water leaves a gap of h = 8 cm from the top. Then, V = 60 ml of unknown liquid that's less dense than water is poured on top of the right branch of the U-pipe. As a result, the water level in the left branch moves by $\Delta h = 2 \text{ cm}$. Water density is $\rho_w = 1000 \text{ kg/m}^3$.

a) What's the density of the unknown liquid? (8 points.)

b) How much can the level of the left branch be raised further by pouring more of the unknown liquid in the right branch? (4 points.)



4. A voltage source with voltage U = 8 V is connected to five resistors, an ideal ammeter and an ideal voltmeter as shown in the figure. The resistors have resistances $R_1 = 2 \Omega$, $R_2 = R_3 = 3 \Omega$, and $R_4 = R_5 = 5 \Omega$.

- a) What's the reading of the ammeter?
- (6 points.)
- b) What's the reading of the voltmeter?
- (2 points.)

