ТО для обы

ОРМО

Открытая региональная межвузовская олимпиада

Общий балл	Дата	Ф.И.О. Жюри	Подпись
63			

Шифр

1. Comparison of Results

Anton's Total Time: $T_A = \frac{5S}{3V}$.

Boris Total Time: $T_B = \frac{3S}{2V}$.

Time Difference:

$$\Delta t = T_A - T_B = \frac{5S}{3V} - \frac{3S}{2V} = \frac{S}{6V}.$$

$V = ?$

Conclusion

Boris finishes the race first, with a time advantage of $\Delta t = \frac{S}{6V}$. ✓

Key Reason: Boris's strategy optimizes acceleration and deceleration phases by allocating time durations. This efficiency allows Boris to achieve a shorter total time.

18Б.

ОРМО
Открытая региональная межвузовская олимпиада

Общий балл	Дата	Ф.И.О. Жюри	Подпись

Шифр

2.

Equations of Motion

Left Ball (θ_1)

~~Position~~ Position as a function of time t:

$$\begin{cases} x_1(t) = v_0 \cos\theta_1 \cdot t, \\ y_1(t) = v_0 \sin\theta_1 \cdot t - \frac{1}{2} g t^2. \end{cases}$$

Right Ball (θ_2)

Position as a function of time t (thrown to the left):

$$\begin{cases} x_2(t) = S - v_0 \cos\theta_2 \cdot t, \\ y_2(t) = v_0 \sin\theta_2 \cdot t - \frac{1}{2} g t^2. \end{cases}$$

Conclustion

The minimum distance between the balls during their flight is:

$$D_{min} = S \cdot \left|\sin\left(\frac{\theta_1 - \theta_2}{2}\right)\right|.$$

105 —

3. The formula for the heat engine efficiency is:

$\eta = 1 - \frac{Q_{released}}{Q_{absorbed}}$, Among $Q_{absorbed}$ is the heat absorbed by the gas in the process of circulation, $Q_{released}$ is the heat released by the gas in the process of circulation.

For ideal monoatomic gaszes, the molar thermal melting of the isoso - capacity process. $C_V = \frac{3}{2}R$, Molar hot melt in isothermal process $C_P = \frac{5}{2}R$ (R is the universal gas constant).

In the (P-T) diagram, The straight line crossing the origin represents the equivariance process (by the ideal gas state equation $PV = nRT$, Deformed into $P = \frac{nR}{V}T$, The slope remains unchanged, that is, the volume V remains unchanged.

Process 1-2 $Q_{12} = nC_V\Delta T_{12}$

Process 2-3 $Q_{34} = nC_V\Delta T_{34}$

Process 4-1 $V = \frac{3}{2}nRT$ $\Delta V_{circulate} = 0$

$\Delta V = Q + W$

$Q_{absorbed} - Q_{released} = W_{net}$

$\eta = 1 \frac{5nC_VT_0}{3nC_VT_0}$ is wrong. It should be $\eta = 1 \frac{Q_{released}}{Q_{absorbed}} = 1 - \frac{3nC_VT}{5nC_VT}$ $= 1 - 0.6 = 0.4$

Convert the effciency into a percentage, $\eta \times 100\% = 40\%$

So, the effciency of the heat engine operating in this cycle is 40%

105

о для
ово

ОРМО
Открытая региональная
межвузовская олимпиада

Общий балл	Дата	Ф.И.О. Жюри	Подпись

Шифр

4. Let the side-length of the ~~?~~ equilateral triangle be r ~~下~~.
According to the electric potential formula of a point charge ~~下~~
$\varphi = \frac{kq}{r}$, where $k = \frac{1}{4\pi\varepsilon_0}$, q is the change of the point charge, and r is the ~~charge of the~~ distance from the point charge.
From $\varphi = \frac{kq_1}{r}$, we can get $q_1 = \frac{\varphi_1 r}{k}$.
Similarly, $q_2 = \frac{\varphi_2 r}{k}$ and $q_3 = \frac{\varphi_3 r}{k}$.

$$F_1 = \sqrt{\left(\frac{\varphi_1\varphi_2 r}{k}\right)^2 + \left(\frac{\varphi_1\varphi_3 r}{k}\right)^2 + 2 \times \frac{\varphi_1\varphi_2 r}{k} \times \frac{\varphi_1\varphi_3 r}{k} \times \frac{1}{2}}$$

$$F_1 = \frac{\varphi_1 r}{k}\sqrt{\varphi_2^2 + \varphi_3^2 + \varphi_2\varphi_3}, \text{ where } k = \frac{1}{4\pi\varepsilon_0}.$$

So, the resultant force F_1 exerted by the second and third balls on the first ball is $F_1 = \frac{\varphi_1 r}{k}\sqrt{\varphi_2^2 + \varphi_3^2 + \varphi_2\varphi_3}$

155

5. First, calcutate the inital density of the surrounding air

The partial ~~pressure~~ pressure of water vapor in the initial state, P_{v1}, with a relative humidity $RH_1 = 10\% = 0.1$ and ~~sta~~ saturated steam pressure $P_s = 9000$ Pa is $P_{v1} = RH_1 \times P_s = 0.1 \times 9000 \text{ Pa} = 900 \text{ Pa}$

The density of water vapor $\rho_{v1} = \frac{P_{v1} M_v}{RT}$, where $M_v = \cancel{18}\ 18 \times 10^{-3}$ kg/mol.

$$\rho_{v1} = \frac{900 \times 18 \times 10^{-3}}{8.31 \times 316} \text{ kg/m}^3 \approx 0.006 \text{ kg/m}^3$$

The initial density of the surrounding air $\rho_1 = \rho_{a1} + \rho_{v1} \approx 1.09 + 0.006 = 1.096 \text{ kg/m}^3$.

Then, calulate the density of the surrounding air in the new state

The new density of the surrounding air $\rho_2 = \rho_{a2} + \rho_{v2} \approx 1.01 + 0.055 = 1.065 \text{ kg/m}^3$.

Next, analyze the buoyant-force and weight relationship.

Substitute $\rho_1 = 1.096 \text{ kg/m}^3$, $\rho_2 = 1.065 \text{ kg/m}^3$, $g = 9.8 \text{ m/s}^2$, and $V = 5000 \text{ m}^3$ into ~~f~~ the formula.

$$W_{dropped} = (1.096 - 1.065) \times 9.8 \times 5000 \text{ N}.$$

$$W_{dropped} = 0.031 \times 9.8 \times 5000 \text{ N} \approx 1519 \text{ N}.$$

−105