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1. Determine who finishes first.

We have the total time for Anton to complete the race $T_A = \frac{5s}{3v}$, and for Boris $T_B = \frac{3s}{2v}$ and.

To compare T_A ~~and~~ T_B, we find a common ~~denomin~~ denominator.

Rewrite $T_A = \frac{5s}{3v} = \frac{10s}{6v}$ and $T_B = \frac{3s}{2v} = \frac{9s}{6v}$

Since $s>0$ and $u>0$ and $\frac{10s}{6v} > \frac{9s}{6v}$, which means $T_A > T_B$. So Boris will finish first.

Anton: using $v^2 = 2a\cdot\frac{s}{3}$, we find $a = \frac{3v^2}{2s}$

Time taken: $t_{A1} = \frac{v}{a} = \frac{2s}{3v}$

Middle $\frac{s}{3}$: Time taken $t_{A2} = \frac{s}{3v}$

Final $\frac{s}{3}$: Time taken $t_{A3} = \frac{2s}{3v}$

Total time: $T_A = t_{A1} + t_{A2} + t_{A3} = \frac{2s}{3v} + \frac{s}{3v} + \frac{2s}{3v} = \frac{5s}{3v}$

Boris: First $\frac{T_B}{3}$: $V = a\cdot\frac{T_B}{3}$. get $a = \frac{3v}{T_B}$.

$S_{B1} = \frac{1}{2}a\left(\frac{T_B}{3}\right)^2 = \frac{vT_B}{6}$

Middle $\frac{T_B}{3}$: $S_{B2} = \frac{vT_B}{3}$

Final $\frac{T_B}{3}$: $S_{B3} = \frac{vT_B}{6}$

Total Distance: $S = S_{B1} + S_{B2} + S_{B3}$

$$= \frac{vT_B}{6} + \frac{vT_B}{3} + \frac{vT_B}{6}$$

$$= \frac{2vT_B}{3}$$

Solving for T_B: $T_B = \frac{3s}{2v}$

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d. Establish the equations of motion Left Ball (θ_1)

① In the horizontal direction, the velocity component is $v_0\cos\theta_1$. According to the formula for uniform linear motion $x = vt$ the horizontal position is $x_1(t) = v_0\cos\theta_1 \cdot t$
In the vertical direction, it is a ~~vert~~ vertical-upward-throwing motion. The inital velocity component is $V_0\sin\theta_1$ ~~Acc~~ According to the formula for uniformly variable linear motion $x = V_0t + \frac{1}{2}at^2$ (where $a=-g$), the vertical position is $y_1(t) = V_0\sin\theta_1 \cdot t - \frac{1}{2}gt^2$

Right Ball (θ_2)

② Position as a function of time t (thrown to the left)

$$\begin{cases} x_2(t) = S - v_0\cos\theta_2 \cdot t \\ y_2(t) = V_0\sin\theta_2 \cdot t - \frac{1}{2}gt^2 \end{cases}$$

③ Derive the distance formula between the two balls, According to the distance formula for two points in space, the square of the distance between the two balls.

$D^2(t)$ is: $D^2(t) = [S - V_0t(\cos\theta_1 + \cos\theta_2)]^2 + [v_0t(\sin\theta_2 - \sin\theta_1)]^2$

Find the time t corresponding to the minimum distance.
After differentiation and calculation, we get $t = \dfrac{S(\cos\theta_1 + \cos\theta_2)}{V_0[(\cos\theta_1+\cos\theta_2)^2 + (\sin\theta_2 - \sin\theta_1)^2]}$

④ Calculate the square of the minimum distance D^2_{min}
Substitute the above-obtained t into $D^2(t)$ and simplify to get:

$$D^2_{min} = S^2 \frac{(\sin\theta_2 - \sin\theta_1)^2}{(\cos\theta_1 + \cos\theta_2)^2 + (\sin\theta_2 - \sin\theta_1)^2}$$

⑤ Simplify using trigonometric identities.
We can finally get the minimum distance $D_{min} = S \cdot \left|\sin\left(\frac{\theta_1 - \theta_2}{2}\right)\right|$

In conclusion, the minimum distance between the two balls during their flight is $S \cdot \left|\sin\left(\frac{\theta_1 - \theta_2}{2}\right)\right|$

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3. Analyze the cyclic process

Process 1-2 : From the diagram we know that this is an isochoric process (since no specific coordinate values are given, assume the temperature increases by ΔT_{12} from ~~st~~ state 1 to state 2) According to the heat - absorption formula for the isochoric process $Q_{12} = \frac{3}{2} nR\Delta T_{12}$, the gas absorbs heat in this process.

Process 2-3 = Assume that the pressure is constant from state 2 to state 3, which is an isobaric process. Let the ~~tempet~~ temperature change be ΔT_{23}. According to the heat - absorption formula for the isobaric process $Q_{23} = \frac{5}{2} nR\Delta T_{23}$. the gas absorbs ~~that~~ heat in this process

Process 3-4. Since there are no coordinates in the diagram, assume it is a heat-release process.

process 4-1 also assume it is a heat - release process

isobaric process $Q_{23} = \frac{5}{2} nR\Delta T_{23}$.

count:

$1-2: Q_{12} = \frac{3}{2} nR(T_2 - T_1)$

$2-3: Q_{23} = \frac{5}{2} nR(T_3 - T_2)$

~~cyclic process~~ The net work of the cyclic process

$$W = p_2(V_3 - V_2) = p_2\left(\frac{nRT_3}{p_2} - \frac{nRT_2}{p_2}\right)$$
$$= nR(T_3 - T_2)$$

The total heat absorbed $Q_{in} = \frac{3}{2} nR(T_2 - T_1) + \frac{5}{2} nR(T_3 - T_2)$

The efficiency of the heat engine

$$\eta = \frac{W}{Q_{in}} = \frac{nR(T_3 - T_2)}{\frac{3}{2}nR(T_2 - T_1) + \frac{5}{2}nR(T_3 - T_2)}.$$

$$Q_{in} = \frac{3}{2}R(2-1) + \frac{5}{2}R(3-2).$$
$$= \frac{3}{2}R + \frac{5}{2}R.$$
$$= 4R$$

$W = R(3-2) = R$

~~η~~ $\eta = \frac{R}{4R} = 0.25 = 25\%.$

1,5

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4 The resulting force F_1 acting on the first ball due to the second and third balls is derived by considering. the expression implifies to: $F_1 = \frac{\phi_1}{k}\sqrt{\phi_2^2 + \phi_3^2 + \phi_2\phi_3}$.

① Express charges in Terms od Potentials.

charges $q_1 = \cancel{\frac{\phi_1 d}{k}}$, $q_2 = \frac{\phi_2 d}{k}$, $q_3 = \frac{\phi_3 d}{k}$

$\frac{\phi_1 d}{k}$

② Coulomb's law: $F_{12} = k\frac{q_1 q_2}{d^2} = \frac{\phi_1\phi_2}{k}$, $F_{13} = \frac{\phi_1\phi_3}{k}$.

③ Angle between forces: 60 %.

Resultant force magnitude

$$F_1 = \sqrt{F_{12}^2 + F_{13}^2 + 2F_{12}F_{13}\cos(60^\circ)} = \frac{\phi_1}{k}\sqrt{\phi_2^2 + \phi_3^2 + \phi_2\phi_3}$$

Final answer

$$F_1 = \frac{\phi_1}{k}\sqrt{\phi_2^2 + \phi_3^2 + \phi_2\phi_3}$$

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5. Initial conditions (10% relative humidity)

First, find the vapor pressure. The relative humidity is 10%, and the saturated vapor pressure at 43 °C is good 9000 Pa. So the vapor pressure $P_v = 0.1 \times 9000\,Pa = 900\,Pa$

Then, calculate the dry-air pressure. The total atmospheric pressure is 100000 Pa, so the dry-air pressure $P_{da} = 100000\,Pa - 900\,Pa = 99100\,Pa$

Density of dry air $\dfrac{99100 \times 0.02897}{8.314 \times 316.15} \approx 1.092\ kg/m^3$.

Density of water vapor: $\dfrac{900 \times 0.018015}{8.314 \times 316.15} \approx 0.00617\ kg/m^3$

Total density: $1.092 + 0.00617 \approx 1.098\ kg/m^3$.

Final conditions.

The vapor pressure $P'_v = 0.9 \times 100000\,Pa - 8100\,Pa = 91900\,Pa$

The density of dry air $\rho_{da2} = \dfrac{P'_{da} M}{RT} = \dfrac{91900 \times 0.02897}{8.314 \times 316.15} \approx 1.013\ kg/m^3$.

The density of water vapor $\rho_{v2} = \dfrac{P'_v M_v}{RT} = \dfrac{8100 \times 0.018015}{8.314 \times 316.15} \approx 0.0555\ kg/m^3$

The total density of the air $\rho_2 = 1.013 + 0.0555 \approx 1.0685\ kg/m^3$.

The buoyant force is given by $F_b = \rho V g$

The inital buoyant force $F_{b1} = \rho_1 V g$

$= 1.098\ kg/m^3 \times 5000\ m^3 \times 9.81\ m/s^2$

$\approx 53906\ N$

The Final buoyant force $F_{b2} = \rho_2 V g$

$= 1.0685\ kg/m^3 \times 5000\ m^3 \times 9.81\ m/s^2$

$\approx 52459\ N$

The difference in buoyant force ΔF_b

$= F_{b1} - F_{b2}$

$= 53906\ N - 52459\ N$

$\approx 1447\ N$

Mass to drop: $\dfrac{1447\ N}{9.81\ m/s^2} \approx 147.5\ kg$

The difference in air density: $0.030\ kg/m^3$

The mass difference: $0.030\ kg/m^3 \times 5000\ m^3 = 150\ kg$.

Thus, the weight of the ballast that must be dropped is 150 kg

Влажность ?

10б