ОРМО
Открытая региональная
межвузовская олимпиада

Общий балл	Дата	Ф.И.О. Жюри	Подпись
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Шифр 141940

1. From the meaning of the question, it can be ifferred that: Anton and Boris use different strategies to compete

① Anton's strategy

List the time taken for Anton's three distance separately

Assuming the initial acceleration is a

starting from rest & to reach speed v

Using $v^2=2a\cdot\frac{S}{3}$, so $a=\cancel{\frac{2S}{3v^2}}\ \frac{3v^2}{2S}$

Let the time taken for the first distance be t_{A_1},

and the time taken for the second and third distance be t_{A_2} t_{A_3}

So $t_{A_1}=\frac{v}{a}=\frac{2S}{3v}$

$t_{A_2}=\frac{S}{3v}$

$t_{A_3}=\frac{2S}{3v}$

Anton's total time: $T_A=t_{A_1}+t_{A_2}+t_{A_3}=\frac{2S}{3v}+\frac{S}{3v}+\frac{2S}{3v}=\frac{5S}{3v}$

② Boris's strategy

The first $\frac{T_B}{3}$: constant acceleration a to reach speed v.

because $v=a\cdot\frac{T_B}{3}$, so $a=\frac{3v}{T_B}$

So distance covered: $S_{B_1}=\frac{1}{2}a\left(\frac{T_B}{3}\right)^2=\frac{vT_B}{6}$

Second $\frac{T_B}{3}$: constant speed v

The distance covered: $S_{B_2}=\cancel{\frac{1}{2}a\left(\frac{T_A}{3}\right)^2}\ \frac{vT_B}{3}$

Final $\frac{T_B}{3}$: Deceleration $-a$ to rest

The distance covered: $S_{B_3}=\frac{vT_B}{6}$

Boris's total ~~time~~ distance: $S=S_{B_1}+S_{B_2}+S_{B_3}=\frac{vT_B}{6}+\frac{vT_B}{3}+\frac{vT_B}{6}=\frac{2vT_B}{3}$

So $T_B=\frac{3S}{2v}$

Time Difference: $\Delta t=T_A-T_B=\frac{5S}{3v}-\frac{3S}{2v}=\frac{S}{6v}$

So Boris finished the race first. with a time advantage of $\frac{S}{6V}$

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$V=?$

2. ~~A~~ Assume the two jugglers simultaneously throw balls to each other with the same intital velocity v_0.
The distance between the jugglers is S.
The height of throwing and catching the ball is the same.
so need to determine the minimum distance between two balls during the flight process.
contable equation
The Left Ball (θ_1)
position as a function of time:

$$\begin{cases} x_1(t) = v_1\cos\theta_1\cdot t, \\ y_1(t) = v_0\sin\theta_1\cdot t - \frac{1}{2}gt^2 \end{cases}$$

The right Ball
position as a function of time

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

Formula for the distance between two balls that can be listed.

So $$D^2(t) = [S - v_0t(\cos\theta_1 + \cos\theta_2)]^2 + [v_0t(si\theta_2 - \sin\theta_1)]^2$$

substitut t into it.

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

using $\sin\theta_2 - \sin\theta_1 = 2\cos(\frac{\theta_1+\theta_2}{2})\sin(\frac{\theta_2-\theta_1}{2})$ and $\cos\theta_1 + \cos\theta_2 = 2\cos(\frac{\theta_1+\theta_2}{2})\cos(\frac{\theta_2-\theta_1}{2})$,

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

so the minimum distance between two balls in flight is

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

одля
скобы

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3. The thermal efficiency can be calculated using the formula: $[\eta = \frac{W}{Q_{in}}]$.

Due to the lack of specific numerical values in the question.

~~$(\eta) = \frac{W}{Q_{in}} =$~~

~~$Q_{in} = nC_p\Delta T$~~

~~$C_p = \frac{5}{2}R$~~

~~$Q_{in} = nC_v\Delta T$~~

~~$C_v = \frac{3}{2}R$~~

From the meaning of the question, it can be inferred that:

1→2 is the isobaric heating process

2→3 is an isothermal expansion process

3→4 is the process of isobaric cooling

4→1 is the process of equal capacitance boosting

(1→2, 2→3) is the endothermic process

(3→4, 4→1) is the exothermic process

Calculate heat from the graph

① 1→2: $Q_1 - Q_2 = \cancel{\Delta}\, C_v n\Delta T = \cancel{12RA}\ 12nR$

② 2→3: $Q_2 - Q_3 = nRT\ln(3) = 12nR\ln 3$

③ 3→4: $Q_3 - Q_4 = -12nR$

④ 4→1: $Q_4 - Q_1 = W_4 - W_1 = -4nR\ln 3$

so net work done is: $W_n = W_4 - W_1 + W_2 - W_3 = 12nR\ln 3 - 4nR\ln 3 = 8nR\ln$

so the total heat absorbed: ~~$Q_H = Q_1 - Q_2 =$~~

$Q_H = Q_1 - Q_2 + Q_2 - Q_3 = 12nR\ln 3 + 12nR$

so $\eta = \frac{W}{Q} = \frac{W_n}{Q_H} = \frac{8\ln 3}{12(1+\ln 3)} \approx \frac{2.197}{6.296} \approx 0.349 \times 100\% = 34.9\% \approx 35\%$

The efficiency is about ~~34.9%~~ 35%

18б

5· From the meaning of the question, it can be inferred that:

① initial conditions

Vapor pressure: $0.1\times9000Pa = 900Pa$

~~Day~~ Dry air pressure: $1\times10^5Pa - 900Pa = 9.91\times10^4Pa$

Density of ~~day~~ dry air: $\frac{9.91\times10^4Pa\times0.02897}{8.314\times361.15} \approx 1.092kg/m^3$

Density of water vapor: $\frac{900\times0.018015}{8.314\times311.15} \approx 0.00617kg/m^3$

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

Final conditions

Vapor pressure: $0.9\times9000Pa = 8.1\times10^3Pa$

Dry air pressure: $1\times10^5Pa - 8.1\times10^3Pa = 9.19\times10^4Pa$

Density of dry air: $\frac{91900\times0.02897}{8.314\times316.15} \approx \cancel{0.10}\ 1.013kg/m^3$

Density of water vapor: $\frac{8100\times0.018015}{8.314\times\cancel{36}316.15} \approx 0.0555kg/m^3$

Total density: $1.013+0.555 \approx 1.0685kg/m^3$

② The buoyancy difference is:

~~Final~~

~~$1.098kg/m^3\times5\times10^3m^3\times9.81m/s^2$~~

$(1.098-1.0685)\times5\times10^3m^3\times9.81m/s^2 \approx 1447N$

③ Convert to Quality

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

Accurately calculate by combining ①, ②, ③

Mass difference: $0.030kg/m^3\times5000m^3 = 150kg$

влажность = ?

10б

So must discard 150kg of items

7. Because the triangle is an equilateral triangle.
Using Coulomb's Law and Vector Addition of forces.
The expression F_1 is:

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

① The potential at a distance d from charge q is $\phi = k\frac{q}{d}$

And $q_1 = \frac{\phi d}{k}$, $q_2 = \frac{\phi_2 d}{k}$, $q_3 = \frac{\phi_3 d}{k}$.

② The force on the first ball is

$$F_{12} = k\frac{q_1q_2}{d^2} = \frac{\phi_1\phi_2}{k},\ F_{13} = \frac{\phi_1\phi_3}{k}$$

Combine equations 1 and 2 together

The resultant force is:

$$F_n = \sqrt{F_{12}^2+F_{13}^2+2F_{12}F_{13}\cancel{\cos(60)}\cos60^\circ} = \frac{\phi_1}{k}\sqrt{\phi_2^2+\phi_3^2+\phi_2\phi_3}$$

15б