место для скобы

ОРМО
Открытая региональная межвузовская олимпиада

Общий балл	Дата	Ф.И.О. Жюри	Подпись
53			

Шифр 041917

1. Two track and field athletes, Anton (A) and Boris (B), compete in running with a distance of S. Each of them followed their own tactics: Anton ran with constant acceleration for the first third of the way, ran with constant velocity v for the second third of the way, and slowed down with the same acceleration for the last third of the way. Boris ran at constat acceleration for the first third of the time, ran at constant speed v for the second third of the time (the same as Anton's), and slowed down for the last third of the time with the same acceleration as at the start. Which of the athletes will finish first? By what time Δt will he overtake his opponent?

A and B use different race distance.

Anton:

First $\frac{S}{3}$: Constant acceleration a. speed v.

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

Time: $t_{A1} = \frac{v}{a} = \frac{2S}{3v}$.

Middle $\frac{S}{3}$: constant velocity v.

Time: $t_{A2} = \frac{S}{3v}$

Final $\frac{S}{3}$: Deceleration and over

Time: $t_{A3} = \frac{2S}{3v}$.

$T_A = t_{A1} + t_{A2} + t_{A3} = \frac{2S}{3v} + \frac{S}{3v} + \frac{2S}{3v} = \frac{5S}{3v}$.

V_0?

Страница

Boris:

First $\frac{T_B}{3}$: $v = a \cdot \frac{T_B}{3}$, so $a = \frac{3v}{T_B}$.

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

Middle $\frac{T_B}{3}$:

Distance covered: $S_{B2} = \frac{vT_B}{3}$

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

$S = S_{B1} + S_{B2} + S_{B3} = \frac{vT_B}{6} + \frac{vT_B}{3} + \frac{vT_B}{6} = \frac{2vT_B}{3}$.

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

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

Boris's Total Time: $T_B = \frac{3S}{2v}$.

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

место для скобы

ОРМО
Открытая региональная межвузовская олимпиада

Общий балл	Дата	Ф.И.О. Жюри	Подпись

Шифр

2. θ_1: $\begin{cases} x_1(t) = v_0\cos\theta_1 \cdot t, \\ y_1(t) = v_0\sin\theta_1 \cdot t - \frac{1}{2}gt^2. \end{cases}$

θ_2: $\begin{cases} x_2(t) = S - v_0\cos\theta_2 \cdot t, \\ y_2(t) = v_0\sin\theta_2 \cdot t - \frac{1}{2}gt^2. \end{cases}$

The squared disance between the two balls is:

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

so: $t = \dfrac{S(\cos\theta_1 + \cos\theta_2)}{v_0[(\cos\theta_1 + \cos\theta_2)^2 + (\sin\theta_2 - \sin\theta_1)^2]}$

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

Using trigonometric identities: ~~sin θ₂~~ $\sin\theta_2 - \sin\theta_1 = 2\cos\left(\frac{\theta_1+\theta_2}{2}\right)\sin\left(\frac{\theta_2-\theta_1}{2}\right)$
and $\cos\theta_1 + \cos\theta_2 = 2\cos\left(\frac{\theta_1+\theta_2}{2}\right)\cos\left(\frac{\theta_2-\theta_1}{2}\right)$,

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

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

10б

Страница

мecто для скобы

ОРМО
Открытая региональная межвузовская олимпиада

Общий балл	Дата	Ф.И.О. Жюри	Подпись

Шифр

3. This problem can be solved by defining thermal efficiency, combiningit with the ideal gas state equation and the first law of thermodynamics, and analyzing the heat absorption and work done during the cycle.

1. The definiting of heat engine efficiency is $\eta = Q_{has} / Q_{release} \times 100\%$
2. Analyze the work done during the cycle process. In a (p-T) diagram, the area enclosed by the cyclic process quadrilateral, and its area can be estimated by counting squares.
3. Analyze the heat absorption during the cycle. For can ideal single gas, the interal energy calculation formula is $E = (\frac{3}{2}) nRT$.

место для скобы

ОРМО
Открытая региональная межвузовская олимпиада

Общий балл	Дата	Ф.И.О. Жюри	Подпись

Шифр

4.

First: The generated electric potential: $\phi = k\frac{q}{d}$.

Charges: $q_1 = \frac{\phi_1 d}{k}$, $q_2 = \frac{\phi_2 d}{k}$, $q_3 = \frac{\phi_3 d}{k}$.

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

Final: Resultant force magnitude:

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

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

2 1 1 1,5 0

Страница

Общий балл	Дата	Ф.И.О. Жюри	Подпись

Шифр

5.

1. 10% relative humidity:
vapor pressure: $0.1 \times 9000 Pa = 900 Pa$
Dry air pressure: $100000 Pa - 900 Pa = 99100 Pa$
Density: $\frac{99100 \times 0.02897}{8.314 \times 316.15} \approx 1.092 kg/m^3$
$\frac{900 \times 0.018015}{8.314 \times 316.15} \approx 0.00617 kg/m^3$
so: $1.092 + 0.00617 \approx 1.098 kg/m^3$

90% relative humidity:
vapor pressure: $0.9 \times 9000 Pa = 8100 Pa$
Dry air pressure: $100000 Pa - 8100 Pa = 91900 Pa$
Density: $\frac{91900 \times 0.02897}{8.314 \times 316.15} \approx 1.013 kg/m^3$
$\frac{8100 \times 0.018015}{8.314 \times 316.15} \approx 0.0555 kg/m^3$
so: $1.013 + 0.0555 \approx 1.0685 kg/m^3$

2. Initial buoyant force: $1.098 kg/m^3 \times 5000 m^3 \times 9.81 m/s^2 \approx 53906 N$
Final buoyant force: $1.0685 kg/m^3 \times 5000 m^3 \times 9.81 m/s^2 \approx 52459 N$
$53906 N - 52459 N \approx 1447 N$

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

4. Difference in air density: $0.030 kg/m^3$
Mass difference: $5000 m^3 \times 0.030 kg/m^3 = 150 kg$

10б

влажность ?