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12/13/22

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Physics SW Final

9) $d = 2.2m \quad \Delta x_B = 1.1cm = 0.011m \quad \Delta x_{off} = 27cm = 0.27m$

$$\frac{1}{2}k\Delta x_B^2 = \frac{1}{2}mv_B^2 \qquad V_B = \frac{d - \Delta x_{off}}{t} \qquad t = \frac{d - \Delta x_{off}}{V_B}$$

$$V_R = \frac{d}{t} \qquad V_R = \frac{d V_B}{(d - \Delta x_{off})}$$

$$k\Delta x_R^2 = m v_R^2$$

$$V_R = \sqrt{\frac{k\Delta x_R^2}{m}} \qquad V_B = \sqrt{\frac{k\Delta x_B^2}{m}}$$

$$\sqrt{\frac{k\Delta x_R^2}{m}} = \frac{d\sqrt{\frac{k\Delta x_B^2}{m}}}{d - \Delta x_{off}}$$

$$\Delta x_R \cdot \sqrt{\frac{k}{m}} = \Delta x_B \cdot \sqrt{\frac{k}{m}} \cdot \frac{d}{d - \Delta x_{off}}$$

$$\Delta x_R = \frac{\Delta x_B d}{d - \Delta x_{off}} = \frac{0.011 \cdot 2.2}{2.2 - 0.27}$$

$$\boxed{\Delta x_R \approx 0.01254m = 1.254cm}$$

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10) $R = 0.2\,m \quad m = 2\,kg \quad h_i = 3\,m$

a) $\Sigma F = ma = mg\sin\theta - \frac{T}{R} \qquad ma + \frac{Ia}{R^2} = mg\sin\theta$

$ma + \frac{T}{R} = mg\sin\theta \qquad ma + \frac{\left(\frac{1}{2}MR^2\right)a}{R^2} = mg\sin\theta$

$ma + \frac{I\alpha}{R} = mg\sin\theta \qquad = a\left(1 + \frac{1}{2}\right) = g\sin\theta$

$a = \frac{g\sin\theta}{3/2} = \frac{2}{3}g\sin\theta = \frac{2}{3}\cdot 10\cdot\sin(30°)$

$$\boxed{a = \frac{10}{3}\ m/s^2}$$

b) $mgh_i = \frac{1}{2}mv_f^2 + \frac{1}{2}I\omega_f^2 = \frac{1}{2}m(\omega_f R)^2 + \frac{1}{2}I\omega_f^2$

$2mgh_i = m\omega_f^2 R_i^2 + \frac{1}{2}mR^2\omega_f^2 = \frac{3}{2}mR^2\omega_f^2 = 3I\omega_f^2$

$3I\omega_f^2 = 2mgh_i \qquad \frac{1}{2}I\omega_f^2 = \frac{1}{3}mgh_i = \frac{1}{3}\cdot 2\cdot 10\cdot 3$

$$\boxed{\frac{1}{2}I\omega_f^2 = 20\,J}$$

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11) $P_A = 4\,atm$ $V_A = 0.5\,L$ $P_B = 4\,atm$ $V_B = 2L$
$P_C = 1\,atm$ $V_C = 2L$ $T_C = 300\,k$

a) $PV = nRT$ $n = \frac{P_C V_C}{RT_C}$ $T_A = \frac{P_A V_A}{nR} = \frac{P_A V_A}{R} \cdot \frac{RT_C}{P_C V_C} = \frac{P_A V_A T_C}{P_C V_C}$

$T_A = \frac{4 \cdot 10^5 \cdot 0.5 \cdot 10^{-3} \cdot 300}{10^5 \cdot 2 \cdot 10^{-3}} = \boxed{300\,k}$

$T_B = \frac{P_B V_B T_C}{P_C V_C} = \frac{4 \cdot 10^5 \cdot 2 \cdot 10^{-3} \cdot 300}{10^5 \cdot 2 \cdot 10^{-3}} = \boxed{1200\,k}$

b)

$A \to B$) Isobaric: $W = -P\Delta V = -4 \cdot 10^5 \cdot (2 - 0.5) \cdot 10^{-3} = \boxed{-600\,J}$

$B \to C$) Isochoric: $\boxed{W = 0}$

$C \to A$) Isothermal: $W = nRT \ln\left(\frac{V_i}{V_f}\right) = \frac{P_C V_C}{RT_C} \cdot R \cdot T_C \cdot \ln\left(\frac{V_i}{V_f}\right) = P_C V_C \ln\left(\frac{V_i}{V_f}\right)$

$W = 10^5 \cdot 2 \cdot 10^{-3} \cdot \ln\left(\frac{2}{0.5}\right) \approx \boxed{277.2589\,J}$

c)

A-B) $\Delta E_{int} = nC_V\Delta T = \frac{P_C V_C}{RT_C} \cdot \frac{3}{2}R \cdot (T_B - T_A) = \frac{P_C V_C}{T_C} \cdot \frac{3}{2}(T_B - T_A)$

$\Delta E_{int} = \frac{10^5 \cdot 2 \cdot 10^{-3}}{300} \cdot \frac{3}{2} \cdot (1200 - 300) = \boxed{900\,J}$

$B \to C$) $\Delta E_{int} = nC_V\Delta T = \frac{P_C V_C}{RT_C} \cdot \frac{3}{2}R \cdot (T_A - T_B) = \frac{10^5 \cdot 2 \cdot 10^{-3}}{300} \cdot \frac{3}{2} \cdot (300 - 1200)$

$\Delta E_{int} = \boxed{-900\,J}$

$C \to A$) $\boxed{\Delta E_{int} = 0 \text{ bc Isothermal.}}$

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d)

$A \to B)\quad Q = nC_p\Delta T = \frac{P_c V_c}{RT_c} \cdot \frac{5}{2} R \cdot (T_B - T_A) = \frac{10^5 \cdot 2 \cdot 10^{-3}}{300} \cdot \frac{5}{2} \cdot (1200 - 300)$

$\boxed{Q = 1500\ J}$

$B \to C)\quad Q = \Delta E_{int} = \boxed{-900\ J}$

$C \to A)\quad Q = nRT \ln\left(\frac{V_f}{V_i}\right) = \frac{P_c V_c}{RT_c} \cdot R \cdot T_c \cdot \ln\left(\frac{V_f}{V_i}\right) = P_c V_c \ln\left(\frac{V_f}{V_i}\right)$

$Q = 10^5 \cdot 2 \cdot 10^{-3} \cdot \ln\left(\frac{0.5}{2}\right) \boxed{\approx -277.2589\ J}$

e)

$e = 1 - \frac{|Q_c|}{|Q_H|} = 1 - \frac{|-900 - 277.2589|}{|1500|} \boxed{\approx 0.2152 = 21.52\%}$

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Physics Final SW

12) S: $X = 10.8$ ly $V = 0.3c$
S':

Earth Probe Epsilon

a) $V = \frac{X}{t}$ $t = \frac{X}{V} = \frac{10.8c \text{ years}}{0.3c} = \boxed{36 \text{ years}}$

b) $t = t_p \gamma$ $t_p = \frac{t}{\gamma} = t\sqrt{1 - v^2/c^2} = 36 \cdot \sqrt{1 - 0.3^2}$ $\boxed{\approx 34.3418 \text{ yrs.}}$

c) S: $X = 10.8$ ly $V_1 = 0.3c$ $V_2 = -0.7c$

$u' = \frac{u - v}{1 - uv/c^2}$ u' is velocity of interceptor by Probe.
u is velocity of interceptor by rest frame
v is velocity of probe by rest frame

$u' = \frac{-0.7c - 0.3c}{1 - (-0.7) \cdot 0.3}$ $\boxed{\approx -0.8264c}$