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Alan
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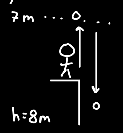
1)



$\Sigma F = ma$ ~ nonzero & doesn't change once in flight

2)

Work = $\vec{F}\cdot\vec{d} = |F||d|\cos\theta$

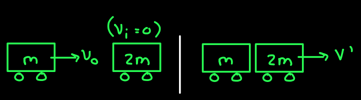
$\therefore$

F = same, d = same $\therefore$ Work A = Work B

3)

A - Force brick on ball > to make ball bounce back

4)



$\therefore$

$\vec{P}$ ~ $mV_0 + 0 = (m+2m)V'$

$\therefore V' = \frac{\cancel{m}V_0}{3\cancel{m}} = \frac{V_0}{3}$

$\therefore$

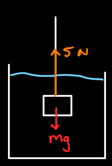
$$\frac{KE_f = \frac{1}{2}(3m)\left(\frac{V_0}{3}\right)^2 = \frac{1}{6}mV_0^2}{KE_i = \frac{1}{2}(m)(V_0)^2 = \frac{1}{2}mV_0^2}$$

$\therefore \frac{1}{6}/\frac{1}{2} = \frac{1}{3}$

7)

Each df contributes $\frac{1}{2}k_bT$

8)



$\therefore \Sigma F = 0$

$0 = T - mg$ ~ $mg = T = 5N$

6)

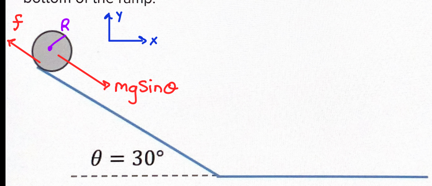
$L = \frac{Q}{m}$

$\therefore m = \frac{Q}{L}$ ~ .45 kg

A uniform cylinder with R=0.2 m and a mass of 2 kg is initially at rest on a ramp at a height of 3 meters above the ground. It then rolls down the ramp without slipping. (Use g=10 m/s^2, I=(1/2) MR^2)

(a) (10 points) Find the linear acceleration of the cylinder as it rolls down the ramp.

(b) (5 points) Find the rotational kinetic energy of the cylinder when it reaches the bottom of the ramp.



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12pt Paragraph B I U A T²

a)

$\Sigma F = ma$

$ma = mg\sin\theta - f$

$\cdot\ fR = \tau = I\alpha = I\frac{a}{r} \Rightarrow f = I\frac{a}{r^2}$

$\therefore$

$ma = mg\sin\theta - I\frac{a}{r^2}$

$ma + I\frac{a}{r^2} = mg\sin\theta$

$a\left(m + \frac{I}{r^2}\right) = mg\sin\theta$

$\therefore$

$a = \frac{mg\sin\theta}{m + I/r^2} = \frac{mg\sin\theta}{m + \frac{\frac{1}{2}mr^2}{r^2}}$

$\therefore$

$\boxed{a = 3.267\ m/s^2}$

(b)

Velocity @ bottom plane:

$mgh = \frac{1}{2}mv^2 + \underbrace{\frac{1}{2}I\omega^2}_{\frac{1}{2}\left(\frac{1}{2}mr^2\right)\left(\frac{V_f}{r}\right)^2}$

$\therefore$

$mgh = \frac{1}{2}mV_f^2 + \frac{1}{4}mV_f^2$

$gh = V_f^2\left(\frac{1}{2} + \frac{1}{4}\right)^{3/4}$

$\therefore$

$V_f = \sqrt{\frac{4gh}{3}} = \boxed{6.261\ m/s}$

$\therefore$

$mgh - \frac{1}{2}mV_f^2 = \frac{1}{2}I\omega^2$

$\therefore KE_{rot.} = \boxed{19.6\ J}$

A heat engine with a monoatomic ideal gas reversibly goes through the cycle in three processes (i.e., A->B, B->C, C->A) as shown in the PV diagram. (1 ATM=10^5 N/m^2, 1 Liter=10^{-3} m^3)

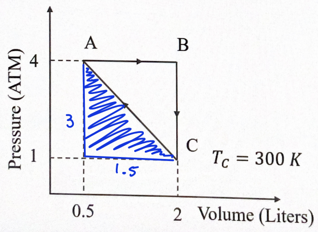
(a) [3 points] Determine T_A and T_B

(b) [3 points] Determine the work done on the gas in each of the three processes.

(c) [3 points] Determine the change of internal energy in each of the three processes.

(d) [3 points] Determine the heat transferred to the gas in each of the three processes.

(e) [3 points] Determine the efficiency of this heat engine.



(a)

$B \rightarrow C$: isovolumetric

$\therefore \frac{P_B}{T_B} = \frac{P_c}{T_c}$

$T_B P_c = T_c P_B$

$T_B = \frac{T_c P_B}{P_c} = \frac{300\,(405200)}{1.013 \times 10^5} = 1200\ K = T_B$

$A \rightarrow B$: isobaric

$\therefore$

$\frac{V_i}{T_i} = \frac{V_f}{T_f}$

$T_A V_B = T_B V_A$

$T_A = T_B V_A / V_B = \frac{1200\,(.5 \times 10^{-3})}{2 \times 10^{-3}} = 300\ K = T_A$

(b) - work

• $A \rightarrow B$:

isobaric: $W = -P \cdot \Delta V = -405200\left([2 \times 10^{-3}] - [.5 \times 10^{-3}]\right)$

$= -607.8\ J$

• $B \rightarrow C$:

isovolumetric $\therefore W = 0$

• $C \rightarrow A$:

Work = - area under curve

$= \left[\frac{1}{2}(3[1.013 \times 10^5])(1.5 \times 10^{-3})\right]$

$+ \left[1.013 \times 10^5\,(1.5 \times 10^{-3})\right]$

$= -379.875\ J$

(c)

$PV = nRT \sim n = \frac{PV}{RT} = 0.08$

$\therefore$

• A → B:

$\Delta E = Q + W$

$Q = nc_p \Delta T = .08(20.8)(900) = \boxed{1497.6 J}$

$\therefore \boxed{\Delta E = 889.8 J}$

• B → C:

isovolum: $\boxed{nc_v \Delta T = Q} = \boxed{-900 J}$

• C → A:

$\boxed{\Delta E = 0}$

(d):

• A → B:

$\boxed{Q = 1497.6 J}$

• B → C:

$\boxed{= -900 J}$

• C → A:

$= +W = \boxed{379.875 J}$

(e)

$e = 1 - \frac{-900}{1877.475} \approx \boxed{1.479}$ $\rightarrow 1 - \frac{Q_C}{Q_H}$

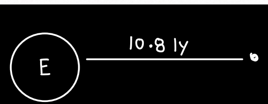
Question 12 15 pts

The star system named Epsilon is a distance 10.8 light-years from the earth. The earth and Epsilon are assumed to be at rest relative to one another. Earth plans to launch a probe that will make the journey from earth to Epsilon at a constant velocity of 0.3c, where c=3.00x10^8 m/s is the speed of light. Define +x to be from earth to Epsilon. (A light-year is the distance traveled by light in 1 year)

(a) How long does the journey take when measured in the Earth frame? (4 points.)

(b) How long does the journey take when measured in the probe's frame? (5 point)

(c) If the Epsilon has an inhabited planet, and the inhabitants launch an interceptor straight at the probe at a velocity of -0.7c along the x direction in the earth-Epsilon rest frame, what would the velocity of the interceptor be as seen by the probe (traveling at +0.3c along the x direction in the earth-Epsilon rest frame?) (6 points)



(a)

To earth, Length $= L_p = 10.8 ly$

$\therefore$

$\Delta t = \frac{L_p}{v} \sim \frac{10.8 ly}{.3c} = \boxed{1.2E-7 s}$

(b)

$L = L_p / \gamma$

$\therefore 10.8 \Big/ \frac{1}{\sqrt{1 - 0.3^2}} = \boxed{10.303 ly}$

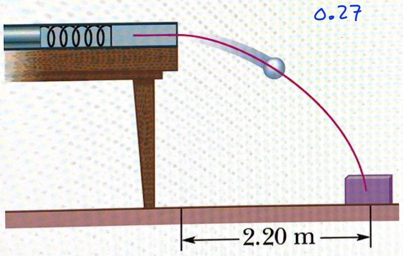
$\therefore$

$\Delta t = \frac{L}{v} \sim \frac{10.303}{.3c} = \boxed{1.145E-7 S}$

c) $u = \frac{.3 - (-.7)}{1 - \frac{.3c(-.7c)}{c^2}} \approx \boxed{0.826 C}$

Two children are playing a game in which they try to hit a small box on the floor with a marble fired from a spring-loaded gun that is mounted on a table. The target box is 2.2 m horizontally from the edge of the table; see the figure below. Bobby compresses the spring 1.1 cm, but the center of the marble falls 27.0 cm short of the center of the box. How far should Rhoda compress the spring for the marble to hit the center of the box? Show your work. (Assume that neither the spring nor the ball encounters friction in the gun. Use g=10 m/s^2.)

0.27



$\therefore \quad \frac{\Delta x}{d}$

$$\frac{.011\text{ m}}{1.93\text{ m}} = \frac{\Delta x}{2.2\text{m}}$$

$$.0242 = 1.93\Delta x$$

$$\Delta x = .0125 \approx \boxed{1.25\text{ cm}}$$