Name____________________________________

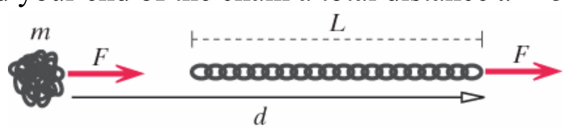
Physics 120 Quiz #6, March 2, 2012

Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

1. Substance A has a large specific heat capacity (on a per gram basis), while substance B has a smaller specific heat capacity. If the same amount of energy is put into a 100-gram block of each substance, and if both blocks were initially at the same temperature, which one will now have the higher temperature?

   a. Substance A
   b. Substance B
   c. They will have equal temperatures.
   d. There is not enough information to answer.

2. A chain of metal links with total mass *m = 3 kg* is coiled up in a tight ball on a low-friction table. You pull on a link at one end of the chain with a constant force *F = 68 N*. Eventually the chain straightens out to its full length *L = 1.0 m*, and you keep pulling until you have pulled your end of the chain a total distance *d = 3.0 m* (diagram is not to scale).



   a. What is the speed of the center of mass of the chain at this instant?

$$W_{Trans} = F\left(d - \frac{L}{2}\right) = 68N \times (3m - 0.5m) = 170J = \tfrac{1}{2} m v_{f,com}^2 \rightarrow v_{f,com} = \sqrt{\frac{2F\left(d - \frac{L}{2}\right)}{m}}$$

$$v_{f,com} = \sqrt{\frac{2F\left(d - \frac{L}{2}\right)}{m}} = \sqrt{\frac{2 \times 68N(3m - 0.5m)}{3kg}} = 10.7\,\tfrac{m}{s}$$

   b. What is the change in energy of the chain?

$$\Delta E = W_{Total} = Fd = 68N \times 3m = 204J$$

   c. In straightening out, the links of the chain bang against each other, and their temperature rises. Assume that the process is so fast that there is insufficient time for significant thermal transfer of energy from the chain to the table, and ignore the small amount of energy radiated away as sound produced in the collisions among the links. Calculate the increase in thermal energy of the chain.

$$\Delta E = \Delta W_{Trans} + \Delta Q \rightarrow \Delta Q = \Delta E - \Delta W_{Trans} = 204J - 170J = 34J$$

Useful formulas:

$\vec{p} = \gamma m\vec{v}$ $\quad k_{eff,parallel} = n_{parallel}k_{individual};\quad stress = Ystrain \to \frac{F}{A} = Y\frac{\Delta L}{L}$

$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ $\quad k_{eff,series} = \frac{k_{individual}}{n_{series}}$

$\vec{v}_{avg} = \frac{\vec{v}_i + \vec{v}_f}{2} \Rightarrow v_{avg} = R\omega_{avg};\quad \text{special case: constant acceleration } \vec{r}_f = \vec{r}_i + \vec{v}_i t + \tfrac{1}{2}\vec{a}t^2;\quad \vec{v}_f = \vec{v}_i + \vec{a}t$

$\vec{F}_g = m\vec{g};\qquad F_C = m\frac{v^2}{R}$

$\vec{F}_{gravity} = \frac{GM_1M_2}{r_{12}^2}\hat{r}_{12}$

$\vec{F}_{spring} = -k\vec{s};\quad \vec{s} = (L - L_o)\hat{s};\quad T = \frac{1}{f} = 2\pi\sqrt{\frac{m}{k_{eff}}}$

$W = \int \vec{F}\cdot d\vec{r} = \Delta KE = -\Delta U$

$U_g = -\frac{GM_1M_2}{r}$

$U_g = mgy$

$U_s = \frac{1}{2}ks^2$

$KE_T = \frac{1}{2}mv^2$

$KE_R = \frac{1}{2}I\omega^2$

$KE = (\gamma - 1)mc^2$

$E_{rest} = mc^2$

Momentum Principle: $\vec{p}_f = \vec{p}_i + \vec{F}_{net}\Delta t$; $\quad \frac{d\vec{p}}{dt} = \vec{F}_{net}$

Angular Momentum Principle: $\vec{L}_f = \vec{L}_i + \vec{\tau}_{net}\Delta t;\quad \vec{\tau} = \vec{r}\times\vec{F}$

$\frac{d\vec{L}}{dt} = \vec{\tau}_{net};\quad \vec{L} = \vec{r}\times\vec{p} = I\vec{\omega};\quad v = R\omega;\quad a = \frac{dv}{dt} = R\frac{d\omega}{dt} = R\alpha$

Position-update: $\vec{r}_f = \vec{r}_i + \vec{v}_{avg}\Delta t = \vec{r}_i + \frac{\vec{p}}{m\sqrt{1+\frac{p^2}{m^2c^2}}}\Delta t$

Energy Principle: $\Delta E = W = \Delta U_g + \Delta U_s + \Delta KE_T + \Delta KE_R$

$W = \int \vec{F}\cdot d\vec{r} + \int \vec{\tau}\cdot d\vec{\theta}$

Constants

$g = 9.8\,\frac{m}{s^2}$

$G = 6.67\times10^{-11}\,\frac{Nm^2}{kg^2}$

$1e = 1.6\times10^{-19}C$

$k = \frac{1}{4\pi\varepsilon_o} = 9\times10^9\,\frac{C^2}{Nm^2}$

$\varepsilon_o = 8.85\times10^{-12}\,\frac{Nm^2}{C^2}$

$1eV = 1.6\times10^{-19}J$

$\mu_o = 4\pi\times10^{-7}\,\frac{Tm}{A}$

$c = 3\times10^8\,\frac{m}{s}$

$h = 6.63\times10^{-34}Js$

$m_e = 9.11\times10^{-31}kg = \frac{0.511MeV}{c^2}$

$m_p = 1.67\times10^{-27}kg = \frac{937.1MeV}{c^2}$

$m_n = 1.69\times10^{-27}kg = \frac{948.3MeV}{c^2}$

$1amu = 1.66\times10^{-27}kg = \frac{931.5MeV}{c^2}$

$N_A = 6.02\times10^{23}$

$Ax^2 + Bx + C = 0 \to x = \frac{-B\pm\sqrt{B^2-4AC}}{2A}$

Vectors

magnitude of a vector: $|\vec{a}| = \sqrt{a_x^2 + a_y^2 + a_z^2}$

writing a vector: $\vec{a} = \langle a_x, a_y, a_z\rangle = |\vec{a}|\hat{a} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$

dot product: $\vec{A}\cdot\vec{B} = AB\cos\theta$

cross product: $C = A\times B = \langle (A_yB_z - A_zB_y), (A_zB_x - A_xB_z), (A_xB_y - A_yB_x)\rangle$

magnitude of the cross product: $\vec{A}\times\vec{B} = AB\sin\theta$

Geometry

Circles: $C = 2\pi r = \pi D \qquad A = \pi r^2$

Triangles: $A = \frac{1}{2}bh$

Spheres: $A = 4\pi r^2 \qquad V = \frac{4}{3}\pi r^3$