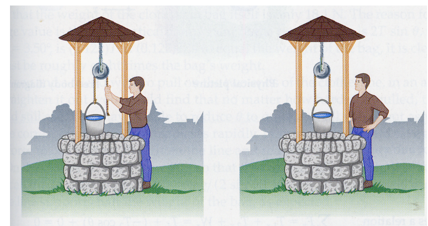
Name______________________________________

Physics 120 Quiz #4, February 10, 2012

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

1. A person hoists a bucket of water from a well and holds the rope, keeping the bucket at rest as in the left photo. Call this situation *A*. A short time later the person ties the rope to the bucket so that the rope holds the bucket in place as in the right photo. Call this situation *B*.



   a. The tension in situation *B is greater than* in situation *A*.
   b. The tension in situation *B is equal to* that in situation *A*.
   c. The tension in situation *B is less than* that in situation *A*.
   d. Three is no way that the individual tensions in the ropes can be determined.

2. A Boeing 737-600 jet prepares to takeoff from a runway. The engines provide constant forward thrust given by $\vec{F}_{thrust} = \langle 173400,0,0\rangle N$ and while the plane moves down the runway friction due to the rubber tires and the concrete runway (with coefficient of kinetic friction given by $\mu_k = 0.2$) opposes the motion of the jet. (All data are obtained from www.boeing.com/commercial/737family/pf/pf_600tech.html)

   a. What is the expression for the net force vector?

$$\vec{F}_{net} = \langle F_{thrust} - F_{friction}, F_{normal} - F_{weight}, 0\rangle$$

   b. Starting from a fundamental principle, if the plane starts from rest and takes off when its velocity is $\vec{v}_f = \langle 77,0,0\rangle \frac{m}{s}$ and not before, what is the mass of the Boeing 737-600 if the jet takes 60s to get to from rest to this final velocity?

$$F_{net} = \frac{dp}{dt} \rightarrow = \langle F_{thrust} - F_{friction}, F_{normal} - F_{weight}, 0\rangle = \left\langle m\frac{dv_x}{dt}, 0, 0\right\rangle$$

$$mv_{fx} - mv_{ix} = m\int_{v_{ix}}^{v_{fx}} dv = (F_{thrust} - F_{friction})\int_{t_i}^{t_f} dt = (F_{thrust} - \mu F_{normal})\Delta t = (F_{thrust} - \mu mg)\Delta t$$

$$m(v_{fx} + \mu g\Delta t) = F_{thrust}\Delta t \Rightarrow m = \frac{F_{thrust}\Delta t}{v_{fx} + \mu g\Delta t} = \frac{173400N \times 60s}{77\frac{m}{s} + \left(0.2 \times 9.8\frac{m}{s^2} \times 60s\right)} = 53464kg$$

   c. How far down the runway does the plane takeoff?

$$\vec{v} = \frac{d\vec{r}}{dt} \Rightarrow dx = v_{fx}dt \Rightarrow \Delta x = \int_{x_i}^{x_f} dx = \int_{t_i}^{t_f}\left(\frac{(F_{thrust} - \mu mg)t}{m}\right)dt = \frac{1}{2}\left(\frac{F_{thrust} - \mu mg}{m}\right)t^2$$

$$\Delta x = \frac{1}{2} \times \left(\frac{173400N - \left(0.2 \times 53464kg \times 9.8\frac{m}{s^2}\right)}{53464kg}\right)(60s)^2 = 2310m$$

Useful formulas:

$\vec{p} = \gamma m\vec{v}$

$\gamma = \dfrac{1}{\sqrt{1-\dfrac{v^2}{c^2}}}$

$\vec{v}_{avg} = \dfrac{\vec{v}_i + \vec{v}_f}{2}$

$\vec{F}_g = m\vec{g}$

$F_{fr} = \mu F_N$

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

$\vec{F}_{spring} = -k\vec{s};\quad \vec{s} = (L - L_o)\hat{s}$

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

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

$U_g = mgy$

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

$KE = \dfrac{1}{2}mv^2$

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

$k_{eff,parallel} = n_{parallel}k_{individual}$

$k_{eff,series} = \dfrac{k_{individual}}{n_{series}}$

$stress = Ystrain \rightarrow \dfrac{F}{A} = Y\dfrac{\Delta L}{L}$

$v_s = \sqrt{\dfrac{k_{IAB}}{m_{atom}}}d$

$k_{IAB} = Yd$

Momentum Principle:

$\vec{p}_f = \vec{p}_i + \vec{F}_{net}\Delta t;\quad \Delta t = \text{large}$

$\vec{p}_f = \vec{p}_i + \vec{F}_{net}dt;\quad dt = \dfrac{\Delta t}{n} = \text{small}$

Position-update:

$\vec{r}_f = \vec{r}_i + \vec{v}_{avg}\Delta t = \vec{r}_i + \dfrac{\vec{p}}{m\sqrt{1+\dfrac{p^2}{m^2c^2}}}\Delta t;\quad \Delta t = \text{large}$

$\vec{r}_f = \vec{r}_i + \vec{v}_f dt;\quad dt = \dfrac{\Delta t}{n} = \text{small}$

$\Delta E = W = \Delta U_g + \Delta U_s + \Delta KE$

Energy principle:

Geometry /Algebra

Circles	*Triangles*	*Spheres*
$C = 2\pi r$	$A = \frac{1}{2}bh$	$A = 4\pi r^2$
$A = \pi r^2$		$V = \frac{4}{3}\pi r^3$

Quadratic equation: $ax^2 + bx + c = 0$,

whose solutions are given by: $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Vectors

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

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

Useful Constants

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

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

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

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

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

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

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

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

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

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

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

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

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

$N_A = 6.02\times10^{23}$

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