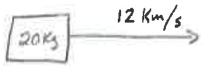
1.



a) It's an energy problem because you are analyzing velocity through the gravitational potential energy, since it can calculate the escape velocity, which will be final velocity in space because of zero forces.

$r = 6{,}371\ km$ $\qquad G = 6.67\times10^{-11}$

$$PE = -\frac{m_1 m_2}{r} G = \frac{-(6\times10^{24} Kg)(100 Kg)}{6{,}371{,}000}(6.67\times10^{-11}\ m^3/Kg s^2) = -6.28\times10^{9} J$$

$$KE = \frac{1}{2} mv^2 = \frac{1}{2}(100 Kg)(12{,}000 m/s)^2 = 7.2\times10^9 J$$

$$E_T = KE + PE = 7.2\times10^9 - 6.28\times10^9 = 9.2\times10^8 J$$

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

$$9.2\times10^8 J = \frac{1}{2}(100 Kg) v^2$$

$$v^2 = 18400000\ m^2/s^2$$

$$\boxed{v = 4289.5\ m/s}$$

Too many S.F.

-1

b) $r_1 = 6{,}371{,}000\ m$

$r_2 = 385{,}000\ km$

$E_T = 9.2\times10^8 J$

$$E_T = -PE + KE = -\frac{(6\times10^{24} Kg)(100 Kg)}{3.85\times10^8 m}(6.67\times10^{-11}\ m^3/Kg s^2) + \frac{1}{2}(100 Kg) v^2$$

$$9.2\times10^8 J = -1.04\times10^8 J + 50 Kg\, v^2$$

$$1.02\times10^9 J = 50 Kg\, v^2$$

$$2.05\times10^7\ m^2/s^2 = v^2$$

$$\boxed{V = 4525.4\ m/s}$$

c) $$F_g = -\frac{m_1 m_2}{r^2} G =$$

$$= -\frac{(6\times10^{24} Kg)(100 Kg)(6.67\times10^{-11}\ m^3/Kg s^2)}{(385{,}000{,}000 m)^2}$$

$100a = -2.7$

$a = -.0027\ m/s^2$

$$\boxed{a = -.0027\ m/s^2}$$

d) $\frac{1}{2}kx^2 = \frac{1}{2}mv^2$

$\frac{1}{2}k(10m)^2 = \frac{1}{2}(100Kg)(12000m/s)^2$

$k\,50m = 7.2\times10^7\,Kg\,m^2/s^2$

$\boxed{k = 144{,}000{,}000\ Kg\,m^2/s^2}$

e) $F = kx = ma$

$\frac{(1.44\times10^8 N)(10m)}{100Kg} = \frac{(100Kg)a}{100Kg}$

$14{,}400{,}000\,m/s^2 = a$

$\boxed{a = 1.44\times10^7\,m/s^2}$ This acceleration is too fast for a person

a > 1 million gravities! it would ultra centrifuge your body into layers of water, protien, lipids, different pulverized bone fragments, etc....

Jim Sherman

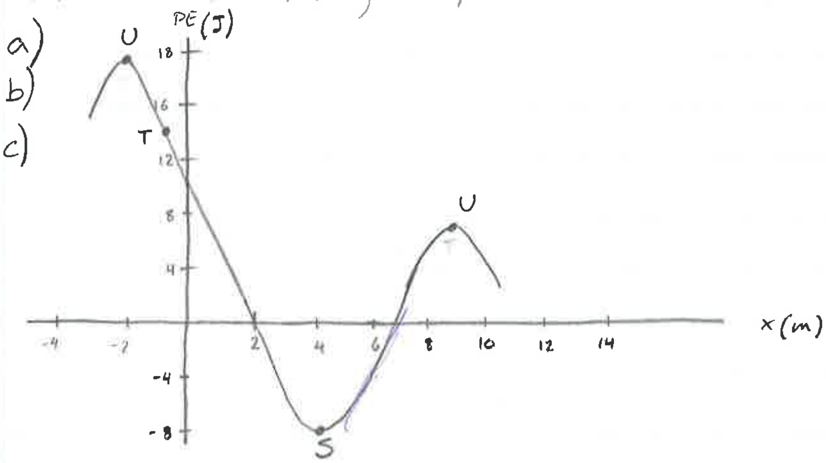
2. 2 Kg mass

starts at $x = 0$ moving 2 m/s left

a)

b)

c)



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

$= \frac{1}{2}(2\,Kg)(2\,m/s)^2$

$= 4\,J$

start at 10 J

$10\,J + 4\,J = 14\,J = max$

d) $PE_6 + KE = 14\,J$

$-2\,J + KE_i = 14\,J$

$KE_i = 16\,J$

$\frac{1}{2}mv^2 = 16\,J$

$mv^2 = 32\,J$

$2\,Kg\,v^2 = 32\,J$

$\sqrt{v^2} = \sqrt{16\,m^2/s^2}$

$v = 4\,m/s$

at $x = 6$, $\boxed{v = 4\,m/s}$

e) $(5.5, -4)$, $(6.5, 0)$

$a = \frac{Y_2 - Y_1}{X_2 - X_1} = \frac{0 + 4}{6.5 - 5.5} = 4\,J/m = \frac{4\,Kg\,m/s^2}{2\,Kg} = 2\,m/s^2$ $\boxed{a = 2\,m/s^2}$

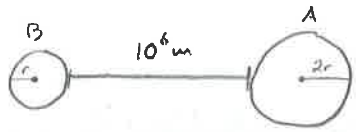
~~$F = -\frac{dPE}{x}$~~

$F_x = -\frac{d(PE)}{dx} = -4\left(\frac{J}{m}\right) = m\vec{a}$

$a = -2\,m/s^2$

2kg

Jim Sherman

3. 

volume

$m \propto V \propto r^3$

a) $d = \frac{m_A}{V_A}$ $\qquad d = \frac{m_B}{V_B}$

$m_A = dV_A$ $\qquad m_B = dV_B$

$m_A = d\left(\frac{4}{3}\pi r^3\right)$ $\qquad m_B = d\left(\frac{4}{3}\pi 8r^3\right)$

$m_A = \frac{4\pi r^3}{3} d$ $\qquad m_B = 8\left(\frac{4\pi r^3}{3}\right) d$

$\boxed{m_A = 8m_B}$

b) $F_A = 1 F_B$

c) $F = m_A a_A$

$a_A = \frac{F}{8m_B}$ $\qquad a_B = \frac{F}{m_B}$

$a_A = a_B$

$a_A = \frac{F}{8m_B} = \frac{F}{m_B} = a_B$

$\frac{a_A}{\frac{F}{8m_B}} = \frac{a_B}{\frac{F}{m_B}} \Rightarrow \frac{\frac{8m_B a_A}{F}}{\frac{8m_B}{F}} = \frac{m_B a_B}{F}\left(\frac{F}{8m_B}\right)$

$a_A = \frac{1}{8}a_B$

$\boxed{a_A = \frac{1}{8}a_B}$

d) $F_A = G\frac{m_1 m_A}{r^2}$ $\qquad F_B = G\frac{m_1 m_B}{r^2}$ $\qquad r =$ 

$F_A = F_B$

$\cancel{G}\frac{\cancel{m_1} m_A}{r^2} = \cancel{G}\frac{\cancel{m_1} m_B}{r^2}$

$\frac{8m_A}{r_A^2} = \frac{m_A}{r_B^2}$ $\qquad \frac{m_A r_A^2}{m_A} = \frac{8m_A r_B^2}{m_A}$

$\sqrt{r_A^2} = \sqrt{8r_B^2}$

$r_A = \sqrt{8}\, r_B$

$\boxed{r_A = \sqrt{8}\, r_B}$

e) $\cancel{mg_A h_A = mg_B h_B}$ → only true when $F_g = mg = \text{const.}$

-1

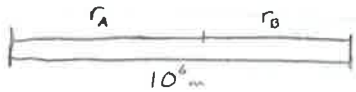
$\frac{m_1 m_2}{r^2} h_A = \frac{m_1 m_2}{r^2} h_B$

$\frac{m_A h_A}{r_A^2} = \frac{8m_B h_B}{r_B^2}$

$\frac{m_A}{r_A} = \frac{m_A}{8r_B}$ $\qquad \frac{1}{r_A} = \frac{1}{8r_B}$

$\boxed{r_A = 8r_B}$

f)



$r_A = \sqrt{8}\, r_B$

$$10^6 m = r_A + r_B$$
$$10^6 m = \sqrt{8}\, r_B + r_B$$
$$\frac{10^6 m}{(1+\sqrt{8})} = \frac{(1+\sqrt{8})\, r_B}{(1+\sqrt{8})}$$
$$r_B = 261{,}203.9\,m$$
$$r_A = \sqrt{8}(261{,}203.9\,m) = \boxed{738{,}796.1\,m}$$

d) $r_A = 738{,}796.1\ m$

$r_B = 261{,}203.8\ m$

e) $r_A = 8 r_B$

$r_A = 8 r_B$

$$10^6 m = r_A + r_B$$
$$= r_A + \frac{r_A}{8}$$
$$= \frac{9}{8} r$$
$$r = \boxed{1{,}125{,}000\,m}$$

g) use momentum, because they have the same momentum at the beginning

$$m_A V_A = m_B V_B$$
$$m_A V_A = 8 m_B V_B$$
$$m_A V_A = \frac{m_A}{8} V_B$$
$$V_A = \frac{1}{8} V_B$$

$$\boxed{V_A = \frac{1}{8} V_B}$$

~~The~~

$\vec{P}_{system} = 0$

$\vec{P}_A = -\vec{P}_B$

h)

$d = 5.52$

3h)

$r_A = 2r_B$

$r_B = 10^4 m$ $\quad r_A = 2\times10^4 m$

$r_e \sim 6.4\times10^6 m$

$m_e \sim 6.0\times10^{24} kg$

$V \propto r^3$, so

$m_A = 8\, m_B$

$r_e = 6.4\times10^2\, r_B$

So, if all planets (A, B, Earth have same density):

$m_e = (6.4\times10^2)^3 m_B \approx 260\times10^6 m_B \approx 3.\times10^8 m_B$

$m_B \approx .25\times10^{-8} m_e \approx 0.75\times10^{16}\,kg$

$m_a = 8\, m_B = 6\times10^{16}\,kg$

We know $V_0 = 0$, so the total kinetic energy they have at the end is equal to the ΔPE

$r_0 = 10^6 m$ $\quad r_f = r_A + r_B = 3\times10^4 m$

$PE = \frac{-m_A m_B}{r} G$

$\Delta PE = \frac{-m_A m_B}{r_f} G - \frac{-m_A m_B}{r_0} G = m_A m_B G\left(\frac{1}{r_0} - \frac{1}{r_f}\right)$

$= 6\times10^{16}\cancel{kg} \cdot 0.75\times10^{16}\cancel{kg} \cdot 6.7\times10^{-11}\frac{N m^2}{\cancel{kg^2}}\Big(\underbrace{\frac{1}{10^6 m}}_{\text{very small}} - \frac{1}{3\times10^4 m}\Big)$

$\approx -10\times10^{17} J = -10^{18} J$

so the KE gained $\sim 10^{18} J = KE_A + KE_B$

So $10^{18} J = \frac{1}{2} m_A v_A^2 + \frac{1}{2} m_B v_B^2$ 2 unknowns

but to conserve momentum, we know from (g)

$v_A = \frac{1}{8} v_B$, or we could do this:

knowing $P_A = P_B \equiv P$, we can say

$$10^{18} J = KE_A + KE_B = \frac{P_A^2}{2m_A} + \frac{P_B^2}{2m_B} = P^2\left(\frac{1}{2m_A} + \frac{1}{2(8)m_A}\right)$$

$$= P^2\left(\frac{8}{16m_A} + \frac{1}{16m_A}\right)$$

$$= \frac{9}{16m_A} P^2$$

$$P^2 = \left(KE_{total}\right)\frac{16}{9} m_A = 10^{18} J \,\frac{16}{\cancel{9}\,3}\, \cancel{6}\,2 \times 10^{16}\, kg\, J$$

$$= \frac{32}{3} \cdot 10^{34}\, kg \,\frac{kg\, m^2}{s^2}$$

$$P^2 \approx 10^{35} \left(kg \frac{m}{s}\right)^2$$

$$P \approx 3 \times 10^{17} kg\, m/s = m_B v_B$$

$$v_B \approx \frac{3 \times \cancel{10^{17}}\,10\, \cancel{kg}\, m/s}{0.75 \times \cancel{10^{16} kg}} \approx 40\, m/s$$

$$v_A = \frac{1}{8} v_B \approx 5\, m/s$$

4. a. • person $x = 7 \cdot t$ $v = 7\,m/s$

• bus $x = 20 + \frac{1}{2}(1)t^2$ $v = 1 \cdot t$

so $7t = 20 + \frac{1}{2}t^2$

$\frac{1}{2}t^2 - 7t + 20 = 0$

$\frac{1}{2}(t^2 - 14t + 40) = 0$

$\frac{1}{2}(t - 10)(t - 4) = 0$

$t = 4$ or 10

person: $v(4) = 7\,m/s$

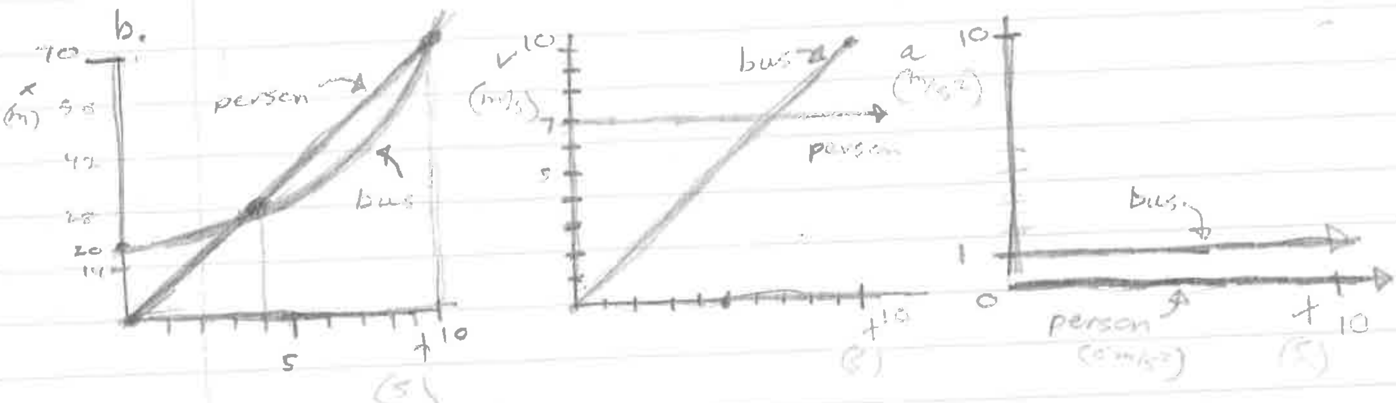
$v(10) = 7\,m/s$

bus $v(4) = 4\,m/s$

$v(10) = 10\,m/s$

you will catch the bus at $t = 4$ seconds, if you were to continue, the bus would pass you at $t = 10\,s$

b.



c. a. person $x = 7\,m/s \cdot t$

bus $x = 30\,m + 0\,m/s\,t + \frac{1}{2}(1\,m/s^2)\,t^2$

so $7\,m/s \times t = 30\,m + \frac{1}{2}(1\,m/s^2)\,t^2$

$\frac{1}{2}t^2 - 7t + 30 = 0$

$\frac{1}{2}(t^2 - 14t + 60) = 0$

the function has no zero's, therefore the position of the person will never be the same as the position of the bus driver - you will not catch the bus.

b.