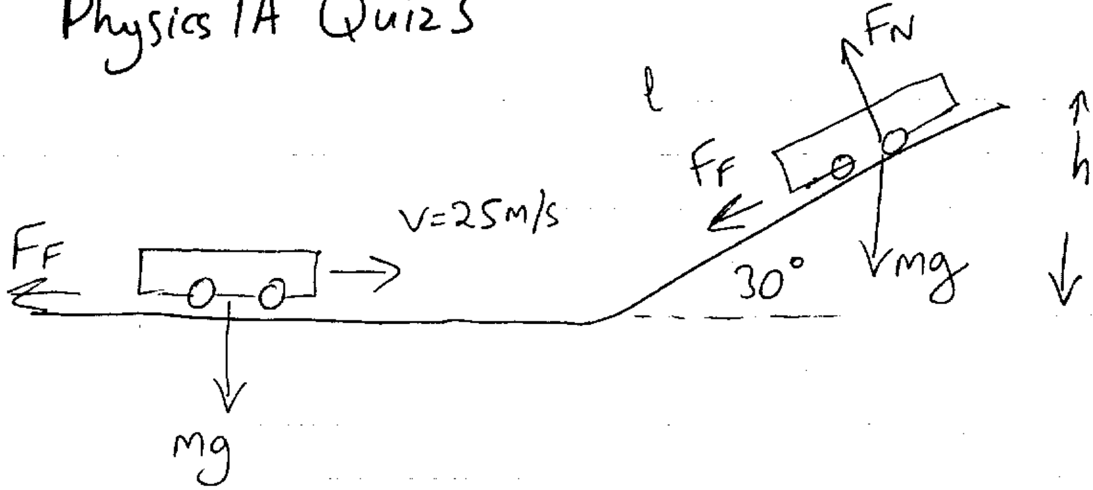
Physics 1A Quiz 3

1.



a) At constant speed, applied force F = friction $F_F = \mu F_N = \mu mg$

Power = force × $\frac{\text{distance}}{\text{time}}$ $= Fv = \mu mg v = 0.1 \times 6000\,N \times 25\,m/s$
$= \underline{15\,kW}$

b) On slope, normal force F_N = component of $\vec{F_W}$ ⊥ to surface

$F_N = mg\cos\theta$, so friction $F_F = \mu F_N = \mu (mg)\cos 30°$
$= 0.1 \times 6000\,N \times \cos 30° = \underline{519.62\,N}$

c) Going uphill: initial KE = final KE + ΔPE + W_F

$\frac{1}{2}mv^2 \quad = 0 \quad + mgh \quad + F_F.l$

Use $h = l\sin\theta$

$\Rightarrow v^2 = 2gl(\sin\theta + \mu\cos\theta)$

or $l = \dfrac{v^2}{2g(\sin 30 + \mu\cos 30)} = \dfrac{25^2}{2 \times 10(0.5 + 0.1 \times 0.866)} = 53.3\,m$

So height gain $h = l\sin\theta = \frac{1}{2}l = \underline{26.6\,m}$.

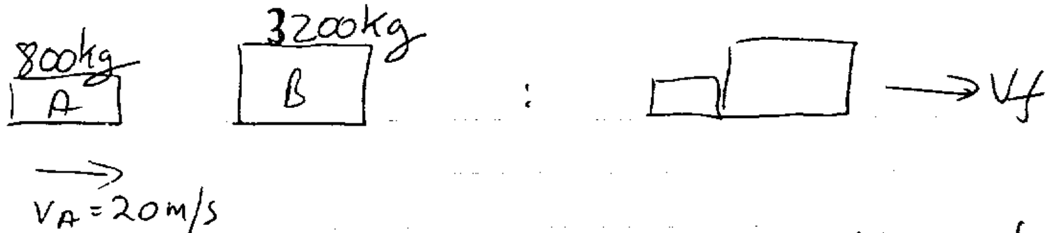
d) For round trip, $(KE_f - KE_i) = \underset{=0}{\Delta PE} - 2F_F.l$

i.e. $\frac{1}{2}mv_f^2 = \frac{1}{2}mv_i^2 - 2l\mu mg\cos\theta$

$v_f^2 = v_i^2 - 4\mu g l\cos 30° = 25^2 - 4 \times 0.1 \times 10 \times 53.3\cos 30$

$\Rightarrow v_f = 20.98\,m/s \approx 21\,m/s$.

2a)



i) Momentum conserved. Initial $p = m_A V_A = 16000\ Ns$

$\Rightarrow \quad V_f = \frac{p}{(m_A + m_B)} = \frac{16000}{800+3200} = \underline{4\,m/s}$

ii) $\Delta KE = KE_i - KE_f = \frac{p^2}{2m_A} - \frac{p^2}{2(m_B+m_A)} = \frac{(16\times10^3)^2}{2\times800} - \frac{(16\times10^3)^2}{2\times4000}$

$= 160\,kJ - 64\,kJ$

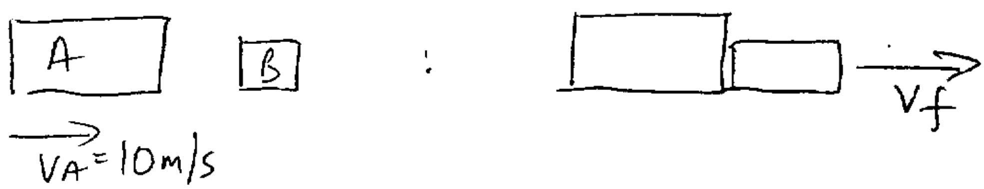
$\Rightarrow \Delta KE = -96\,kJ$ lost to deformation, etc.

iii) Impulse on Bug $F_{av}\Delta t = \Delta(m_A V) = m_A(V_f - V_A)$

$= 800\,(20-4) = 12800\ Ns$

$\Delta t = 0.2s \Rightarrow \underline{F_{av} = 64\,kN}$.

b) Now:



i Initial $p = 3200\,kg \times 10\,m/s = 32\times10^3\,Ns$. $\Rightarrow V_f = \frac{p}{m_A+m_B} = \underline{8\,m/s}$.

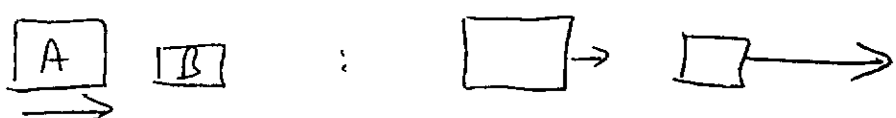
ii) $\Delta KE = KE_i - KE_f = \frac{p^2}{2\times3200} - \frac{p^2}{2\times4000}$

$= 160\,kJ - 128\,kJ \quad = \underline{32\,kJ}$ lost

iii) Impulse on Bug B $F_{av}\Delta t = 800\,kg \times (V_f - 0)$

$\Rightarrow \quad F_{av} = \underline{32\,kN}$, less than (a).

c) Elastic case:



Bug B now flies off with $V_{Bf} \approx 2V_{Ai} \approx 20\,m/s$ $(m_A \gg m_B)$

No KE lost, but Bug has impulse $F_{av}\Delta t = m_A(V_{Af} - 0)$

$\Rightarrow$ av. force $F_{av} \approx \frac{800\times20}{0.2} = \underline{80\,kN}$, largest yet

So occupants of "rubber Bug" experience larger, painful forces in collision