CH. 15 ENERGY METHODS SECTION 15-1

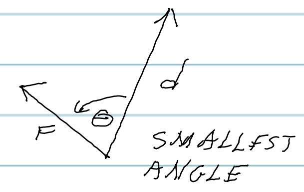
WORK - SIMPLE

$W = U_{12} = \Sigma F_{\parallel} d$ "ΣF" CONST IN MAG. ∥

$W = |\Sigma F|\,|d| \cos(\theta)$ "ΣF" CONSTANT - REL. θ

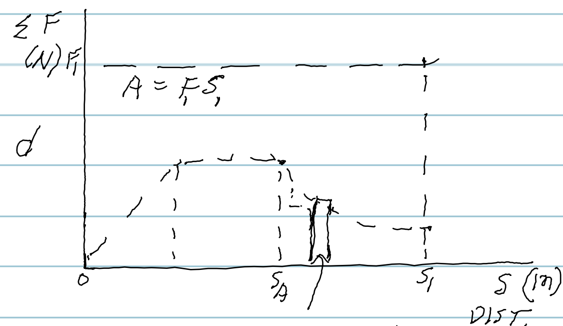
3-D $W = \Sigma F \cdot d$ "ΣF" CONSTANT - $d \Rightarrow$ ST. LINE

NET FORCE; VECTOR ALGEBRA DOT PRODUCT



$W_{0 \to S_1} = F_1 \cdot S_1$

AREA UNDER F VS d = WORK



$dA = \Sigma F(s)\,ds$

$$W = \int_{S_1}^{S_2} \Sigma F(s)_{TAN}\,ds = \int_{T_1}^{T_2} \Sigma F(t)_{TAN}\,V\,dT$$

$$W = \int da = \int_{S_A}^{S_1} \Sigma F(s)\,ds$$

WORK ENERGY PRINCIPLE

$KE_1 + W = KE_2$

KEY POINT

$$\Sigma W = \int \Sigma F_{TAN} \cdot ds = \Sigma F_{TAN} \cdot S$$

$W = KE_2 - KE_1$

POWER

$$P_{AV} = \frac{W}{T} = \frac{\Delta W}{\Delta T}$$

ΔW: JULES, J, FT-lbs, in-lbs; ΔT: sec

P_{AV}: W, $\frac{FT \cdot lbs}{s}$

EXAMPLE - FLAT PANEL TV'S $\Rightarrow$ \$26/year $\Rightarrow$ 5 hrs/day, 1 KW·hr = 11¢

$P_w = \frac{W}{T}$ $W = P \cdot T = 1\,KW \cdot hr$

ENERGY

$\#hr/yr = 365 \times 5\,hr/day = 1825\,\frac{hr}{yr}$ @ \$26 $\frac{\$}{hr} = \frac{\$26}{1825\,hr} = .014/hr$

$$\frac{\$}{hr} = \left(.014\,\frac{\$}{hr}\right)\left(\frac{1\,KW \cdot hr}{.11\,\$/hr}\right) = .13\,KW \cdot hr \Rightarrow \text{DRAW } .13\,KW = 130\,W$$

SECTION 15-1 NOTES + PROBLEMS

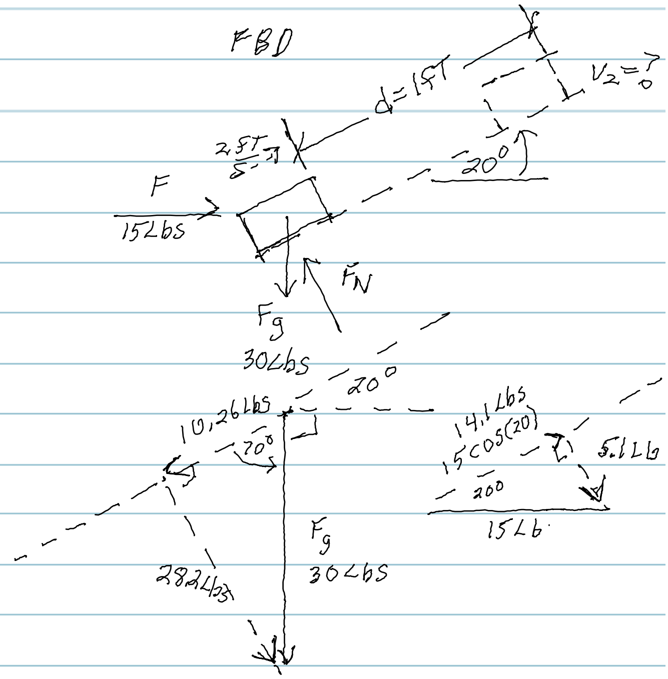
$$P_{AVG} = \frac{W}{T} = \frac{KE_2 - KE_1}{\Delta T}$$

$$P_{INST} = \Sigma F_{TAN} \cdot V = \Sigma F_{TAN} \cdot V = |F||V| \cos(\theta)$$

15-4 EXAMPLE – "ΣF_{TAN}"

GIVEN: $F_g = W = 30\,Lbs$, $V_1 = 2\,\frac{FT}{S}$

FIND: $V_2 = ?$



SOLUTION: $W = U_{12} = \Delta KE$

$$W = (\Sigma F_{TAN})\, d \qquad KE_1 = \tfrac{1}{2} m V_1^2$$

$$KE_2 = \tfrac{1}{2} m V_2^2$$

$$F_g = mg$$

$$m = \frac{F_g}{g} = \frac{30\,Lbs}{32.2\,\frac{FT}{S^2}} = .9317\,SL$$

GOVERNING EQUATION: $W = \Delta KE$

$$\Sigma F_{TAN} \cdot d = \tfrac{1}{2} m V_2^2 - \tfrac{1}{2} m V_1^2$$

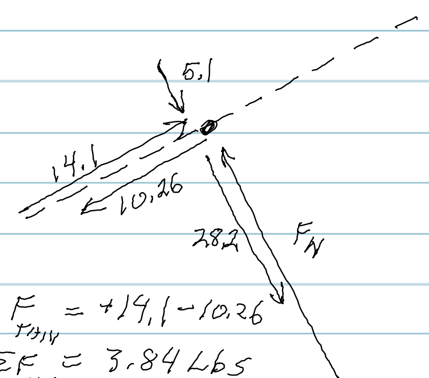
$$\tfrac{1}{2} m V_2^2 = \Sigma F_{TAN} \cdot d + \tfrac{1}{2} m V_1^2$$

$$V_2^2 = \frac{2\Sigma F_{TAN} \cdot d}{m} + V_1^2$$

$$V_2 = \sqrt{\frac{2\Sigma F_T \cdot d}{m} + V_1^2}$$

$$V_2 = \sqrt{\frac{2(3.84\,Lbs) \cdot 1\,FT}{.9317\,SL} + \left(2\,\frac{FT}{S}\right)^2}$$

$$V_2 = 3.50\,\frac{FT}{S}$$



$$\Sigma F_{TAN} = +14.1 - 10.26$$

$$\Sigma F_{TAN} = 3.84\,Lbs$$

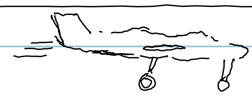
SECTION 15-1 HOMEWORK EXAMPLES (CONT.)

15-6 GIVEN: $V_1 = 0\ \frac{m}{s}$, $V_2 = 12\ \frac{m}{s}$, $\Delta T = 0.02\ \text{sec}$, $m = .45\,\text{kg}$

FIND: $P_{av} = ?$

SOLUTION: $P_{av} = \frac{\Delta KE}{T} = \frac{\frac{1}{2} m V_2^2 - \frac{1}{2} m V_1^2}{T} = \frac{\frac{1}{2}(.45\,\text{kg})(12\ \frac{m}{s})^2 - 0}{.02\,\text{sec}} = 1.62 \cdot 10^3\ W = \underline{\underline{1.62\ KW}}$

SENSIBLE UNITS



15-9 GIVEN: $F_g = 32{,}000\ \text{Lbs}$, $V_1 = 0$

$V_2 = 200\ \text{MPH}\left(\frac{88\ \frac{ft}{sec}}{60\ \text{MPH}}\right) = 293.3\ \frac{ft}{s}$

FIND: $d = S = ?$

SOLUTION: $W = \Delta KE = \frac{1}{2} m V_2^2$

$F \cdot d = \frac{1}{2} m V_2^2$

$m = \frac{F_g}{g} = \frac{32{,}000\ \text{Lbs}}{32.2\ \frac{ft}{s^2}} = 993.8\ sL$

$d = \frac{\frac{1}{2} m V_2^2}{F} = \frac{\frac{1}{2}(993.8\ sL)(293.3\ \frac{ft}{s})^2}{45{,}000\ \text{Lbs}}$

$\underline{\underline{d = 950\ ft}}$

5-11 GIVEN: $\Sigma T = 45{,}000 - 5.25\ S$ (Lbs), $m = 993.8\ sL$, $d = 950\ ft$

$\leftarrow ft$

FIND: $V(s) = ?$ @ $S = 950\ ft$

SOLUTION: $W = \Delta KE$

$W = \frac{1}{2} m V_2^2$

$W = \int_0^{950\ ft} \Sigma F\, ds = \int_0^{950} (45{,}000 - 5.2\ S)\, ds = 45{,}000\ S - \frac{5.2}{2} S^2 \Big|_0^{950} = 45{,}000(950) - 2.6(950) - 0$

$W = 4.04 \cdot 10^7\ ft \cdot \text{Lbs}$

$W = \frac{1}{2} m V_2^2 \Rightarrow V_2^2 = \frac{2W}{m} \Rightarrow V_2 = \sqrt{\frac{2W}{m}}$

$V_2 = \sqrt{\frac{2(4.04 \cdot 10^7)}{993.8\ sL}} = \underline{\underline{285\ \frac{ft}{s}}}$

SECTION 15-2/3 POTENTIAL ENERGY & CONSERVATIVE FORCES

CONSERVATIVE FORCE – PATH INDEPENDENT
FORCE OF GRAVITY
EM FORCES
SPRING

PATH DEPENDENT – FRICTION

GRAVITY $\Delta W = \Delta PE_g$ $\quad PE_g = mgh$ (J) $\quad h \cong 32\ km$

$PE_g = mgR_E^2\left(\frac{1}{r_2} - \frac{1}{r_1}\right)$ $\quad r_1 > R_e + 40\ km$

SPRING $V = PE_{SP} = \frac{1}{2}ks^2$ (POTENTIAL) $\quad s = (x - x_0)$

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

CONSERVATION OF ENERGY

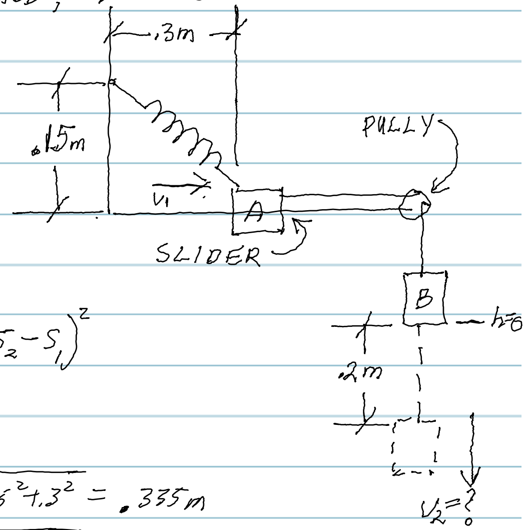
SNAPSHOTS ① SNAPSHOT ②

$KE_1 + PE_1 + SE_1 + W - U_{NG} = KE_2 + PE_2 + SE_2$

FRICTION

15-92 GIVEN: $k = 700\ \frac{N}{m}$, $m_a = 14\ kg$, $m_b = 18\ kg$, UNSTRETCHED, $V_1 = 1\ m/s$

FIND: $V_2 = ?$ @ $h = -.2m$



SOLUTION:

① $KE_{1a} + KE_{1b} + \cancel{PE_{1a}} + \cancel{PE_{1b}} + \cancel{SE_1} + \cancel{W} - \cancel{U_{12\,NG}} =$

② $KE_{2a} + KE_{2b} + \cancel{PE_{2a}} + PE_{2b} + SE_2$

$\frac{1}{2}m_aV_1^2 + \frac{1}{2}m_b(V_1)^2 = \frac{1}{2}(m_a + m_b)V_2^2 - m_bgh + \frac{1}{2}k(S_2 - S_1)^2$

$\frac{1}{2}(m_a + m_b)V_2^2 = \frac{1}{2}(m_a + m_b)V_1^2 + mgh + \frac{1}{2}k(S_2 - S_1)$

$V_2^2 = V_1^2 + \frac{2mgh - k(S_1 - S_2)^2}{(m_a + m_b)}$

$S_1 = \sqrt{.15^2 + .3^2} = .335m$

$S_2 = \sqrt{.15^2 + (.5)^2} = .522\ m$

$(S_2 - S_1) = .522 - .335 = .187m$

$V_2 = \sqrt{\left(1\frac{m}{s}\right)^2 + \frac{2(18kg)(.2m) - \left(700\frac{N}{m}\right)(.187m)^2}{(14kg + 18kg)}}$

$\underline{\underline{V_2 = 1.56\ \frac{m}{s}}}$