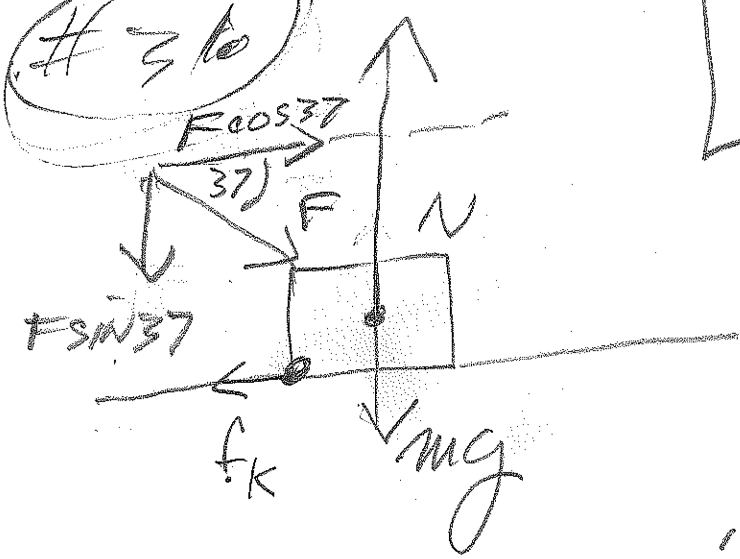
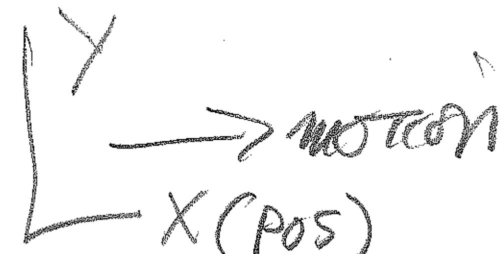
Diagrams for Hints:
Quiz 5 – Ch 4

#36

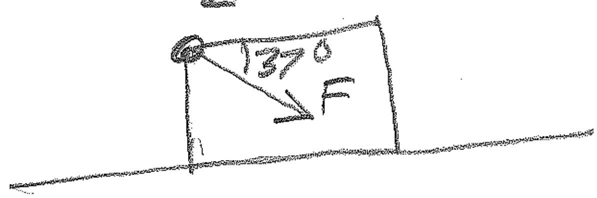




x (pos) along motion

reality

point of force application



$$\sum F_x = \text{pos} - \text{neg}$$

$$ma_x = F\cos 37 - f_K$$

$$\sum F_y = ma_y = 0 = \text{pos} - \text{neg}$$

$$0 = N - mg - F\sin 37$$

$$N = mg + F\sin 37 > mg$$

$a_y = \frac{dv_y}{dt} = 0$ since motion along x

$$f_k = \mu_k \cdot N$$

$$ma_x = F\cos 37 - \mu_k \cdot N$$

$$ma_x = F\cos 37 - \overbrace{\mu_k \cdot (mg + F\sin 37)}^{f_k}$$

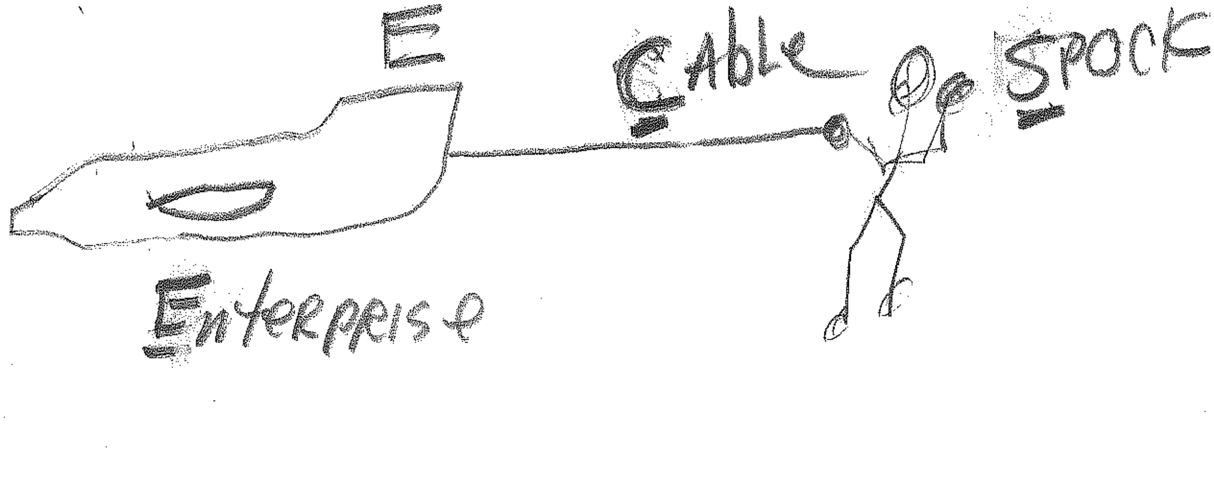
TYPICALLY

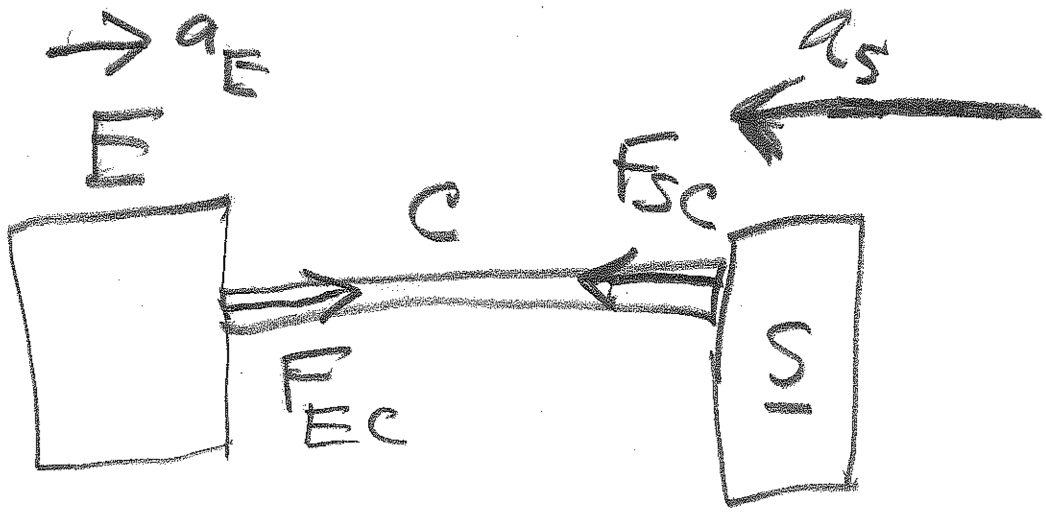
(A) solve for a_x OR

(B) solve for F, given a_x

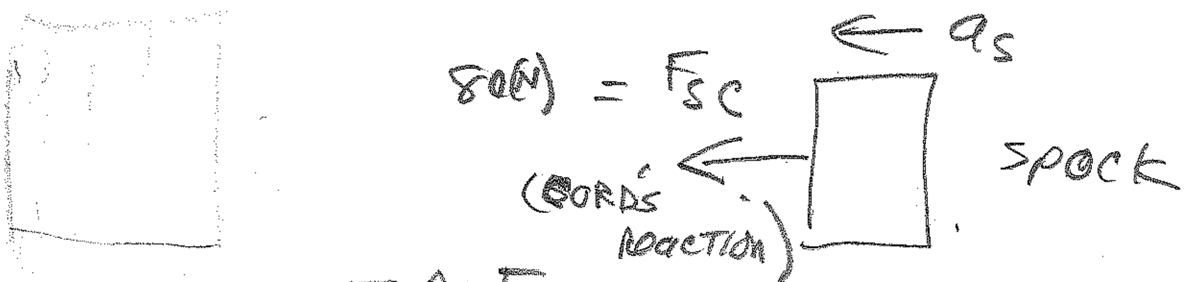
#44 Diagram

STAR TREK (newton's 3RD LAW lab





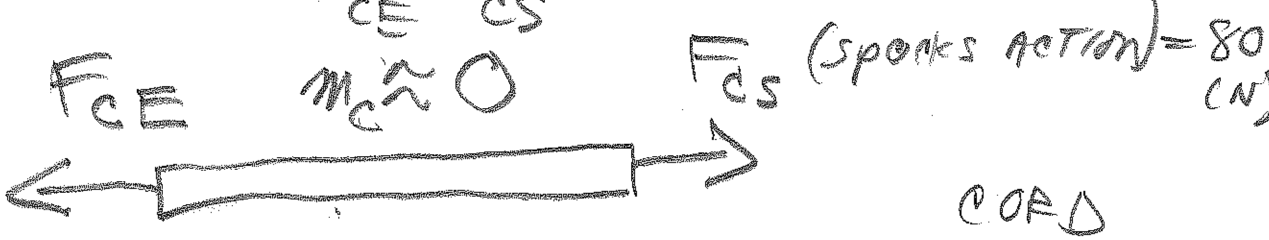
$$F_{SC} = m_S \cdot a_S$$

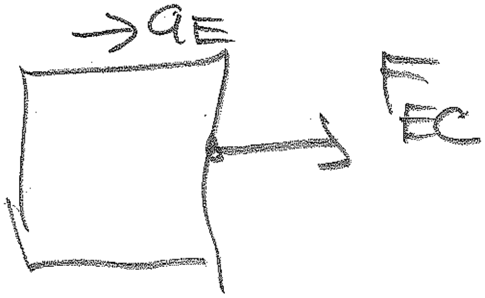


$$\boxed{m_c a_c = 0}$$

$$F_{CE} \approx F_{CS}$$

$$m_c \approx 0$$





Enterprise

Newton's 3RD LAW:

$F_{SC} = F_{CS}$ and $F_{CE} = F_{EC}$

SUMMARY

$m_E a_E = m_S a_S$

$F_{EC} = F_{SC}$

SPOCKS $F_{CS} = 80(N)$

(a) $F_{SC} = 80(N) = m_S a_S$

(b) $\rightarrow a_S = \dfrac{F_{SC}}{m_S} = \dfrac{80(N)}{105\,kg}$

NOTE: $F_{EC} = 80(N) = m_E a_E$

$a_E << a_S$, $m_E >> m_S$

#96

See mvphysics.com

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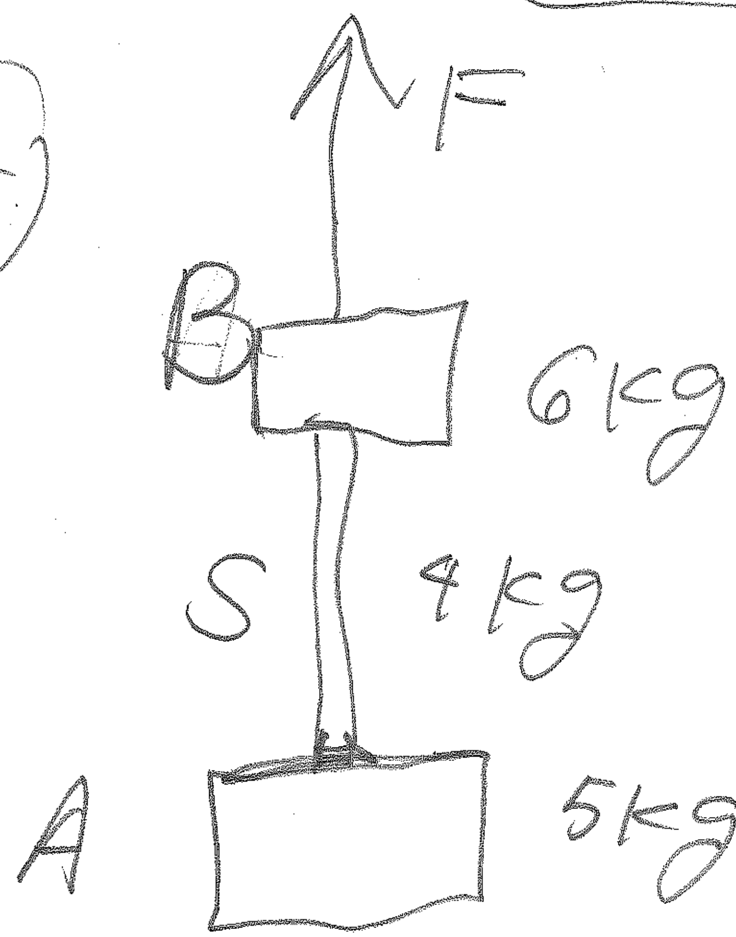
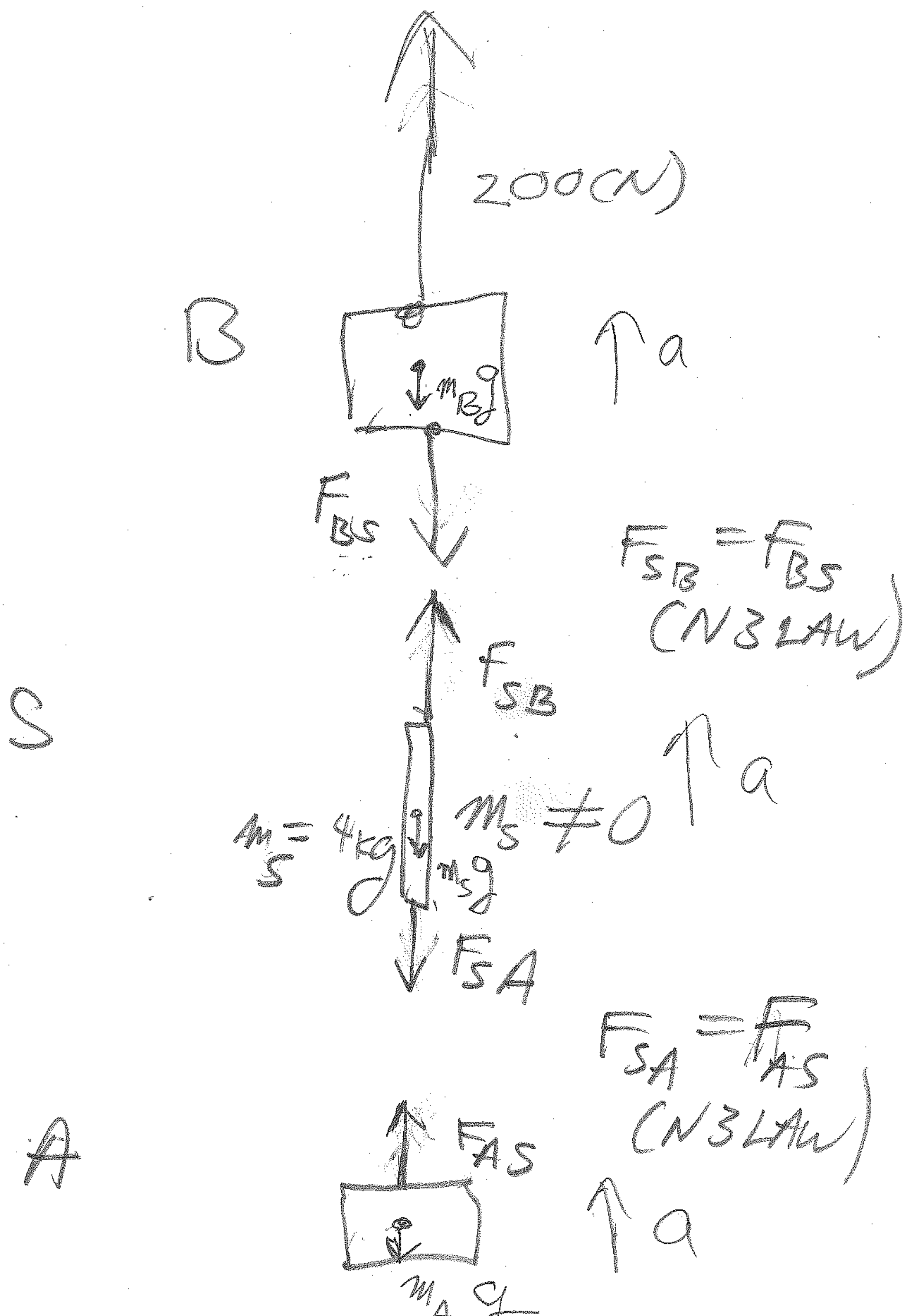


Isolate each object


200(N)
B
a
$m_B g$
F_{BS}
$F_{SB} = F_{BS}$
(N3 LAW)
F_{SB}
S
a
$m_S \neq 0$
$m_S = 4kg$
$m_S g$
F_{SA}
$F_{SA} = F_{AS}$
(N3 LAW)
A
F_{AS}
a
$m_A g$

B

$$m_B a = pos - neg$$

$$m_B a = 200 - m_B g - F_{BS}$$

S

$$m_S a = pos - neg$$

$$m_S a = F_{SB} - F_{SA} - m_S g$$

A

$$m_A a = F_{AS} - m_A g$$

3 Equations + 3 unknowns:

$$\begin{aligned} m_B a &= 200 - m_B g - F_{BS} \\ m_S a &= F_{BS} - F_{SA} - m_S g \\ m_A a &= F_{SA} - m_A g \end{aligned}$$

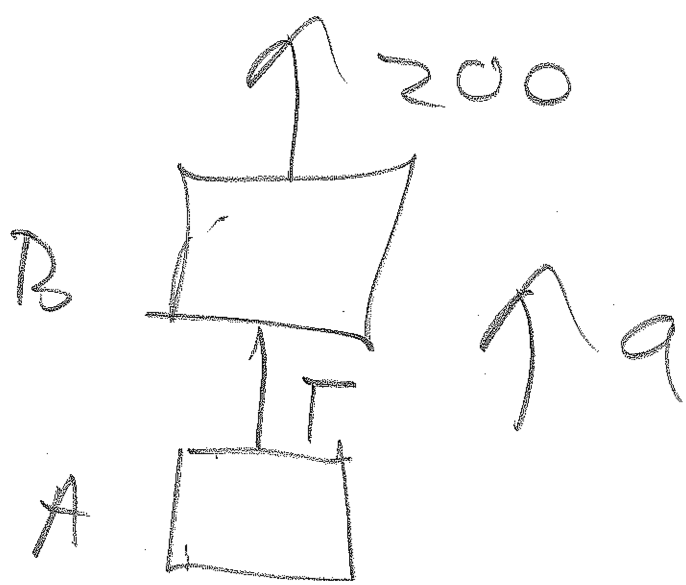
a, $F_{BS} = F_{SB}$, $F_{SA} = F_{AS}$

ADD TO cancel F_{BS} and F_{SA} TO GET a.

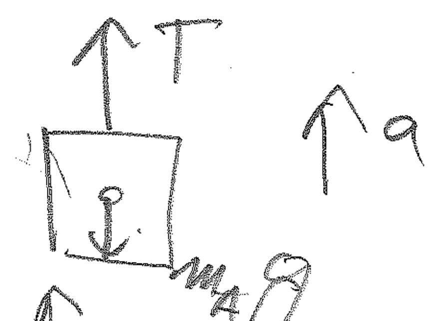
NOTE: typically: $m_S = 0$

$F_{BS} = F_{SA} = T$ (NOTICE)

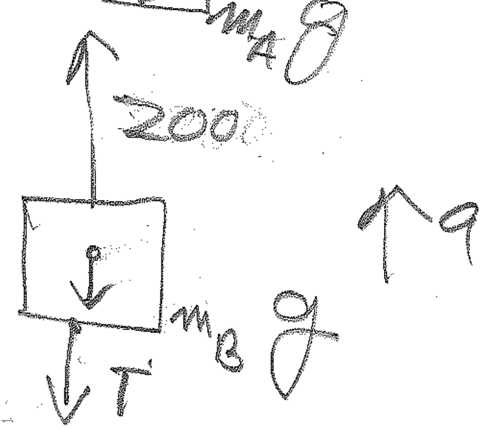
Famous equation:



Isolate (A):



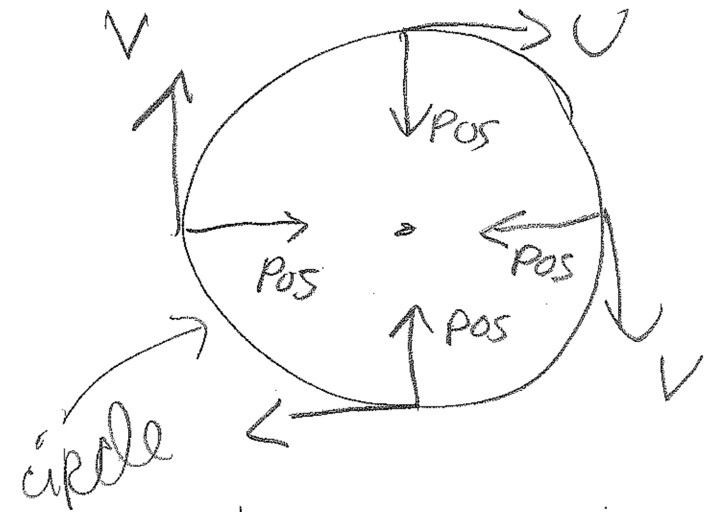
Isolate (B):



A| $m_A a = T - m_A g$

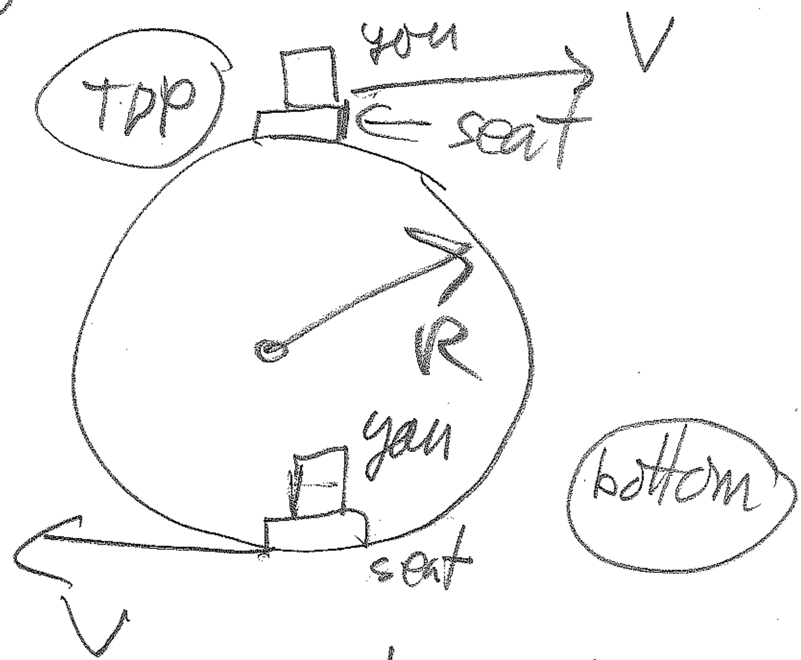
B| $m_B a = 200 - T - m_B g \Longrightarrow$ unknowns: a, T

Basic Rule centripetal force



Positive direction toward center.

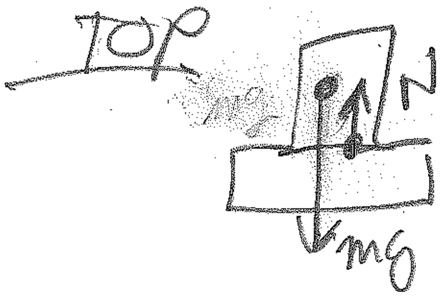
EX 5.23



HORIZONTAL

TOP

↓ POS

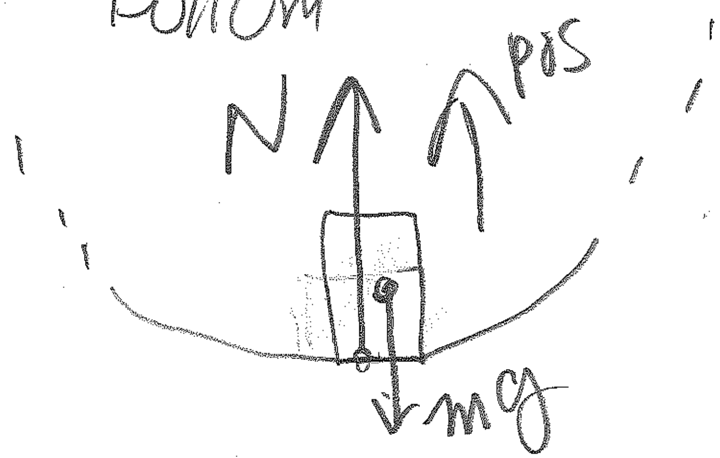


$$\boxed{\sum F_c = \frac{mv^2}{R} = POS - neg}$$

TOP | $\frac{mv^2}{R} = mg - N$

$N_{TOP} = mg - \frac{mv^2}{R} < mg$

Bottom



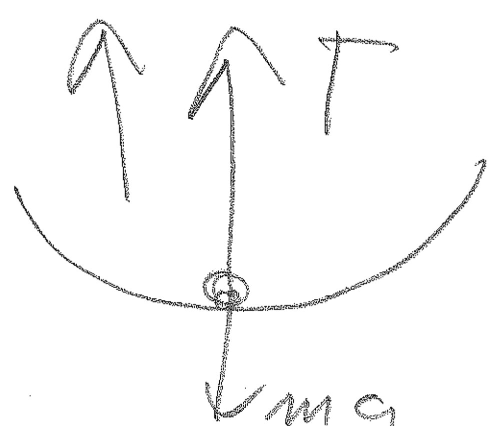
$\sum F_c = \frac{mv^2}{R} = pos - mg$

$\frac{mv^2}{R} = N - mg$

$N_{Bot} = mg + \frac{mv^2}{R} > mg$

astrophysics 4.2

POS



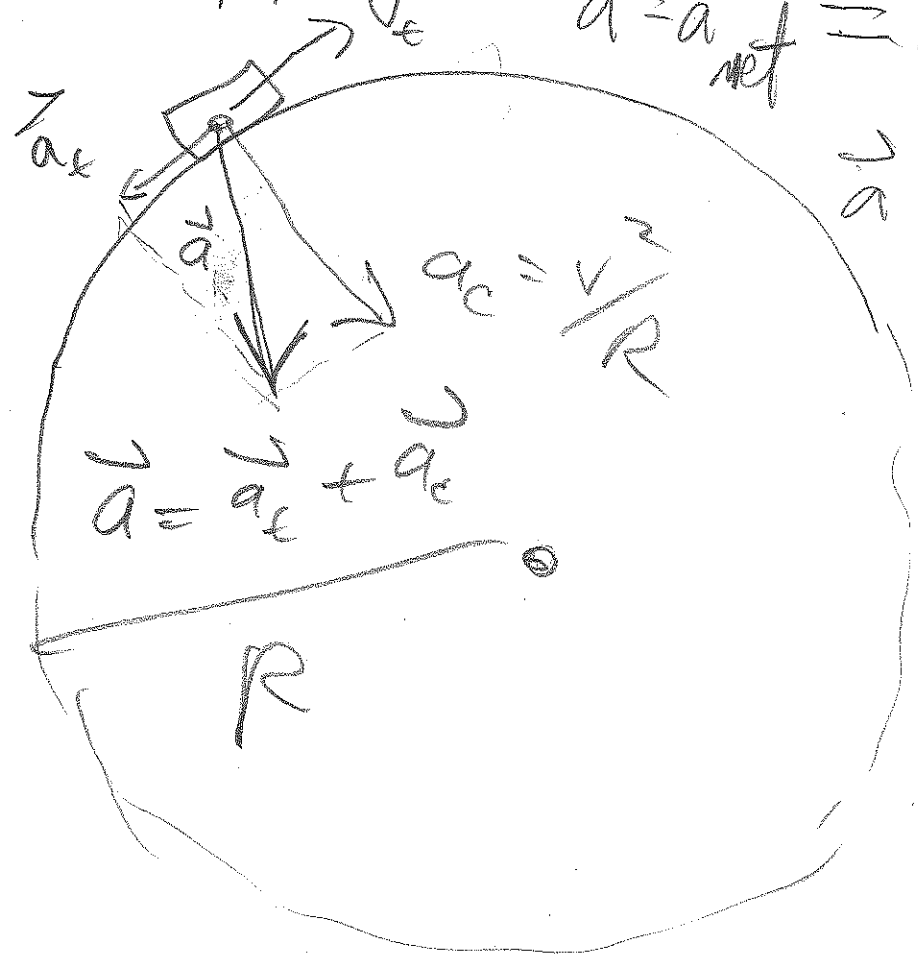
$$\frac{mv^2}{R} = T - mg$$

$$T = \frac{mv^2}{R} + mg > mg$$

action 4c 3

physics

$$\vec{a} = \vec{a}_{net} = \vec{a}_t + \vec{a}_c$$



$\vec{a}$ does not point to center unless at top.

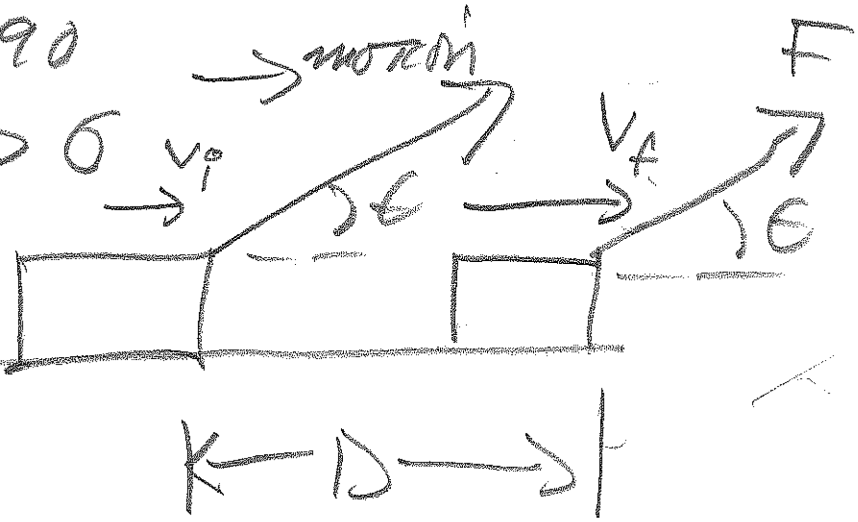
CH6:

WORK = $F \cdot \cos\theta \cdot D$

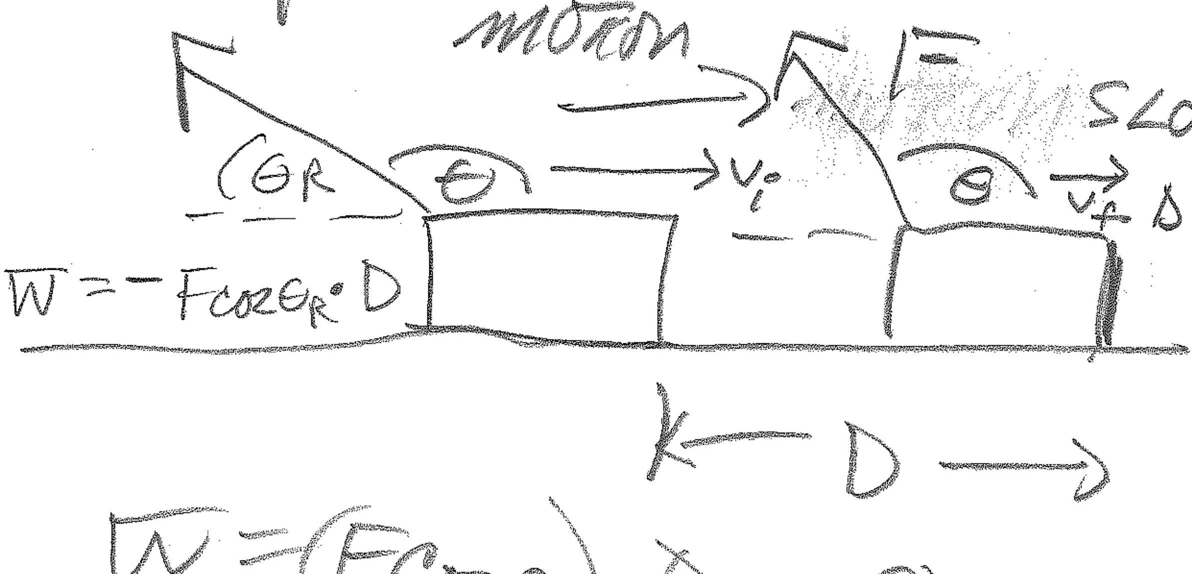
$0 < \theta < 90$

$W > 0$

speeding up



WORK = (component of force along motion) $\cdot$ DISTANCE



$W = -F\cos\theta_R \cdot D$

SLOWING DOWN

$W = (F\cos\theta)\cdot D < 0$; $90° < \theta < 180$

BIG Fact!

IF $\vec{F} \perp$ motion,

$W = 0$

~~[illegible]~~ centripetal (uniform speed) motion.

$$dW = \vec{F} \cdot d\vec{r}$$

$$= |\vec{F}_c| \cdot |d\vec{r}| \cos 90$$

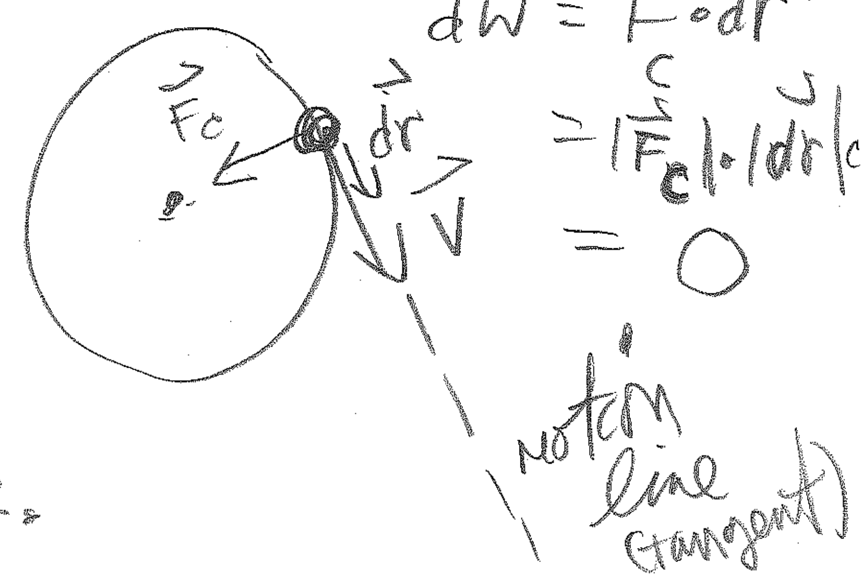
$$= 0$$

$\vec{dr} = dx\hat{i} + dy\hat{j} + dz\hat{k}$

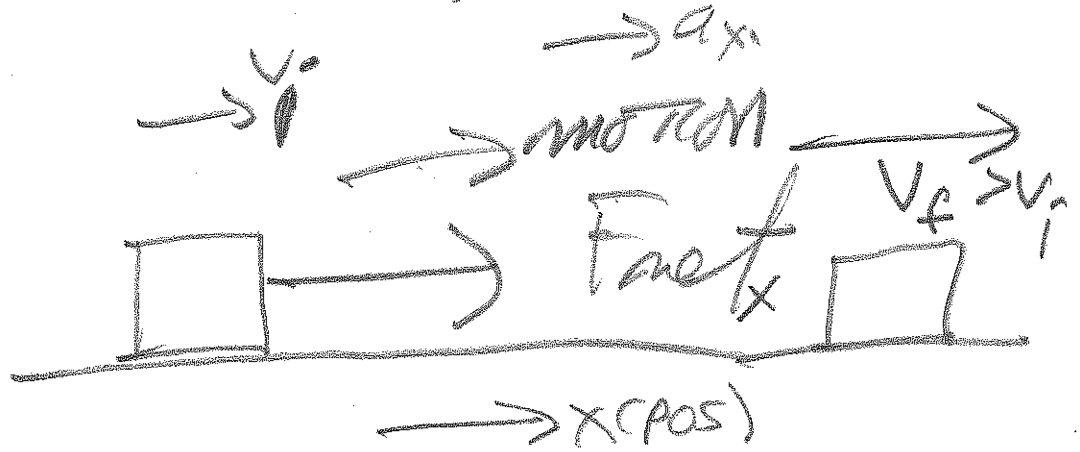
OR

$\vec{dr} = (dx, dy, dz)$,

a 3-vector.



WORK ENERGY THEOREM



Ch5 $F_{net_x} = m \cdot a_x$ (N2LAW)

$$F_{net_x} = m\left(\frac{v_f^2 - v_i^2}{2 \cdot D}\right) \quad \underline{Ch2}$$

$$F_{net_x} \cdot D = \frac{m}{2}\left(v_f^2 - v_i^2\right)$$

$$\boxed{W_{net} = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2}$$

WORK-ENERGY THEOREM

3D Insertion; calculus derivation in 3-D.

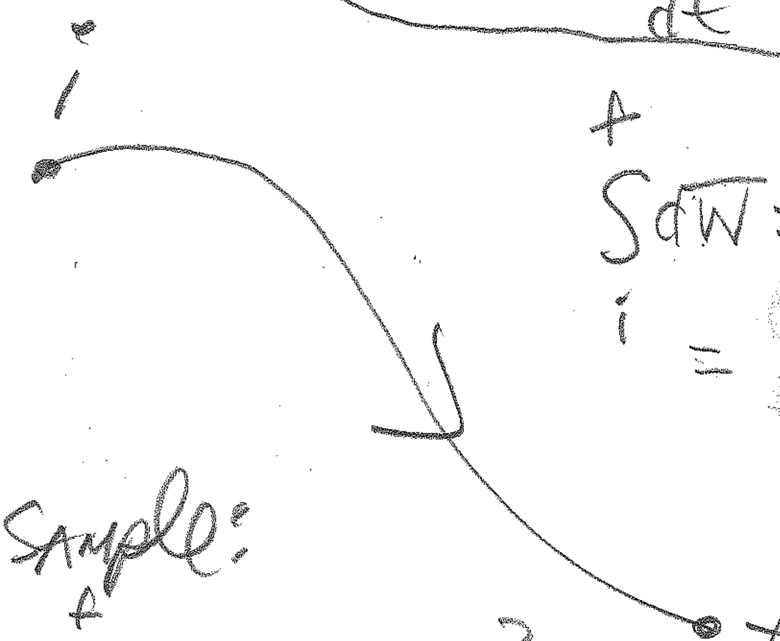
$$dW = \vec{F} \cdot d\vec{r}$$

$$dW = ma_x\,dx + ma_y\,dy + ma_z\,dz$$

$$= m v_x\,dv_x + m v_y\,dv_y + m v_z\,dv_z$$

$$a_x = \frac{dv_x}{dt}$$

$$a_x\,dx = \frac{dv_x}{dt} \cdot dx = dv_x \cdot \frac{dx}{dt} = dv_x \cdot v_x \,*$$



$$\int_i^f dW = \frac{1}{2} m\left(v_{x_f}^2 + v_{y_f}^2 + v_{z_f}^2\right) - \frac{1}{2} m\left(v_{x_i}^2 + v_{y_i}^2 + v_{z_i}^2\right)$$

$$= \frac{1}{2} m|\vec{v}_f|^2 - \frac{1}{2} m|\vec{v}_i|^2$$

* Sample:

$$\int_i^f m v_x\,dv_x = \frac{1}{2} m v_{x_f}^2 - \frac{1}{2} m v_{x_i}^2$$

$$\int u\,du = \frac{u^2}{2} + C$$

Math 1

$W_{net} = \Delta KE$

$KE \equiv \frac{1}{2} \cdot mass \cdot (speed)^2$

WORKS IN 2-D
and 3-D,
using calculus.

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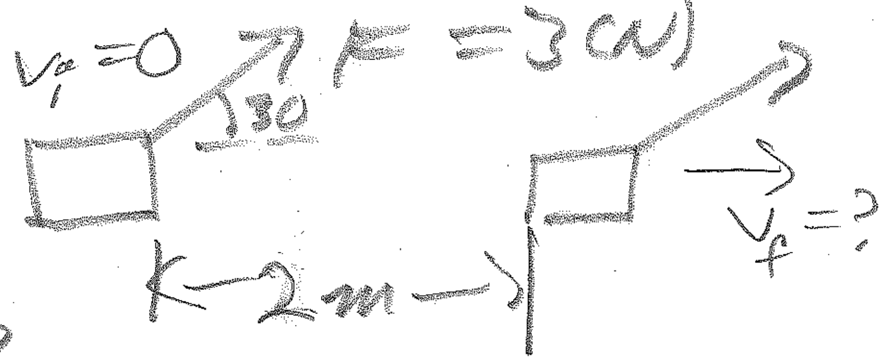
3 QUICK EXAMPLES

(A)



$m = 1\,kg$

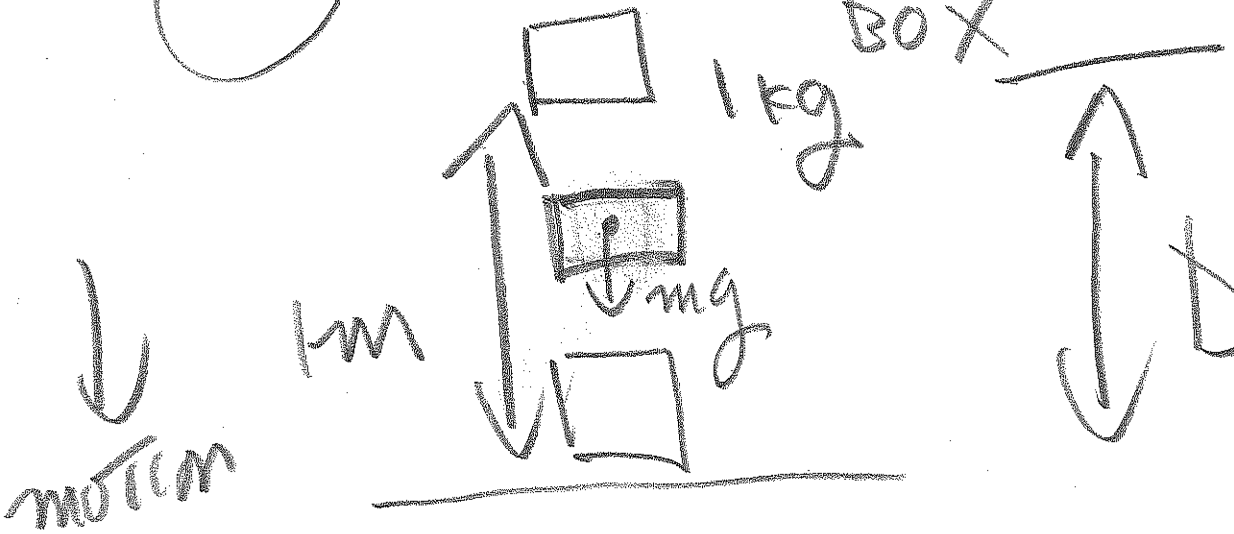
$W_{net} = (F\cos\theta)\cdot D$

$\frac{1}{2} m V_f^2 = 3 \cdot \cos 30 \cdot 2$ (Joules)

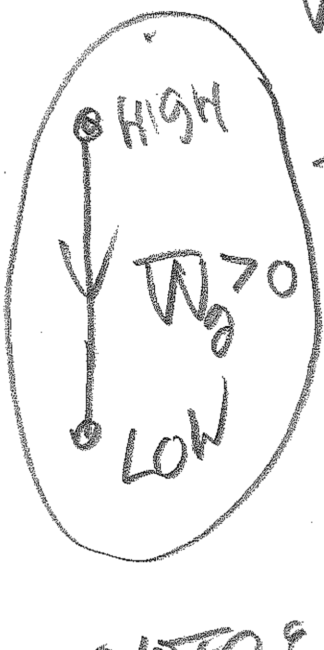
$\longrightarrow V_f = \sqrt{12 \cdot \cos 30} = 3.2\ m/s =$ speed

B

I DROP a BOX



$\overline{W}_g = ?$



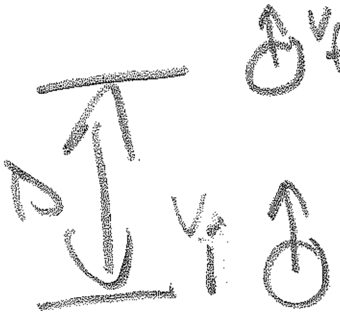
$\overline{W}_g = F \cdot \cos\theta \cdot D$

$\overline{W}_g = mg \cdot \cos 0 \cdot (1)\ J$

$W_g = +9.8$ JOULES

NOTE:

THROW A Ball UPWARD



$\overline{W}_g = mg\cos 180 \cdot D$

$= -mg \cdot D < 0$

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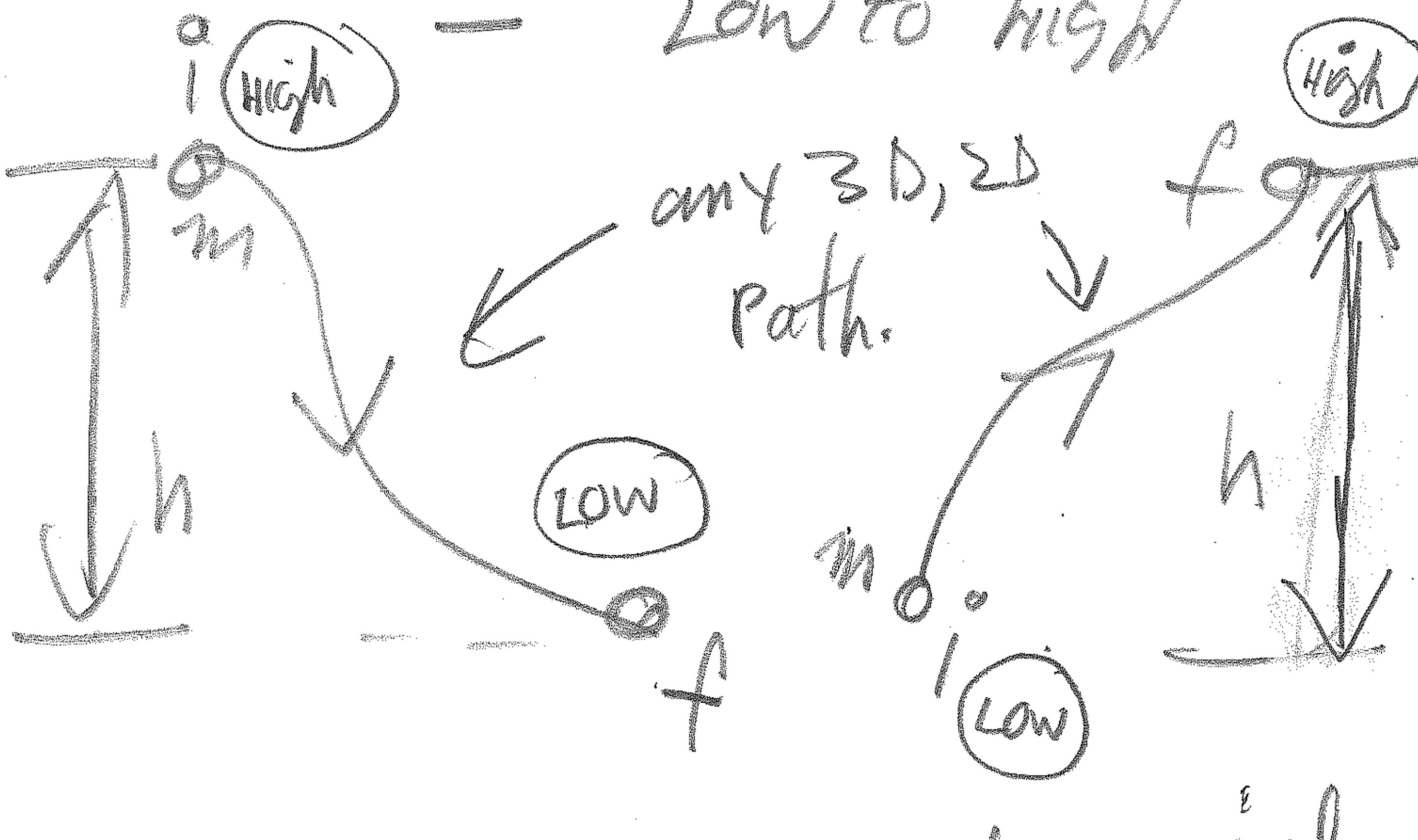
$W_g = \pm mgh$; h = VERTICAL DISTANCE

$+$ HIGH TO LOW

$-$ LOW TO HIGH



W_g ONLY Depend on VERTICAL DISTANCE (3D calculus)

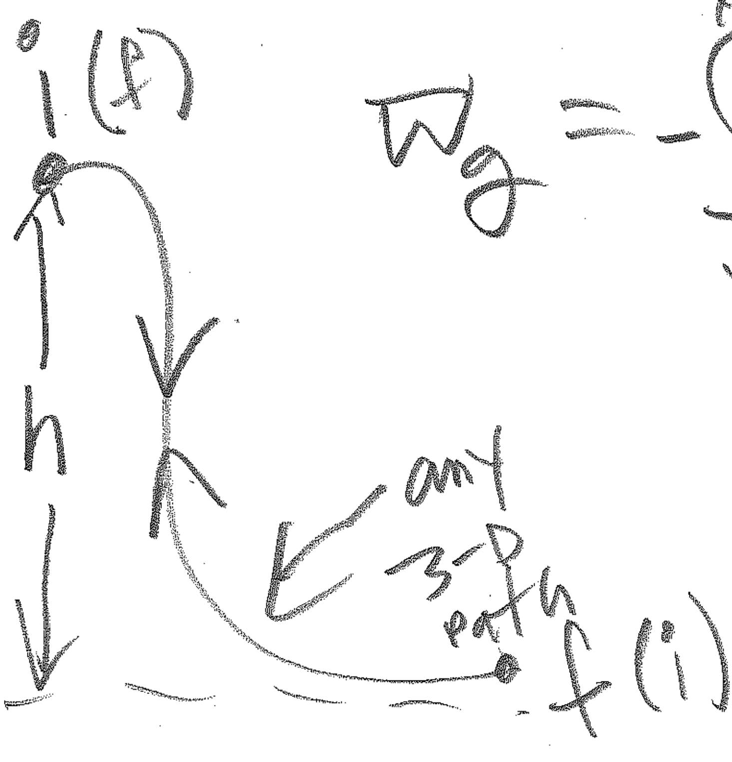
3-D calculus derivation:

$$dW_g = \underbrace{\cancelto{0}{F_x dx} + F_y dy + \cancelto{0}{F_z dz}}_{\text{differential for any 3-D path.}}$$

y(pos)

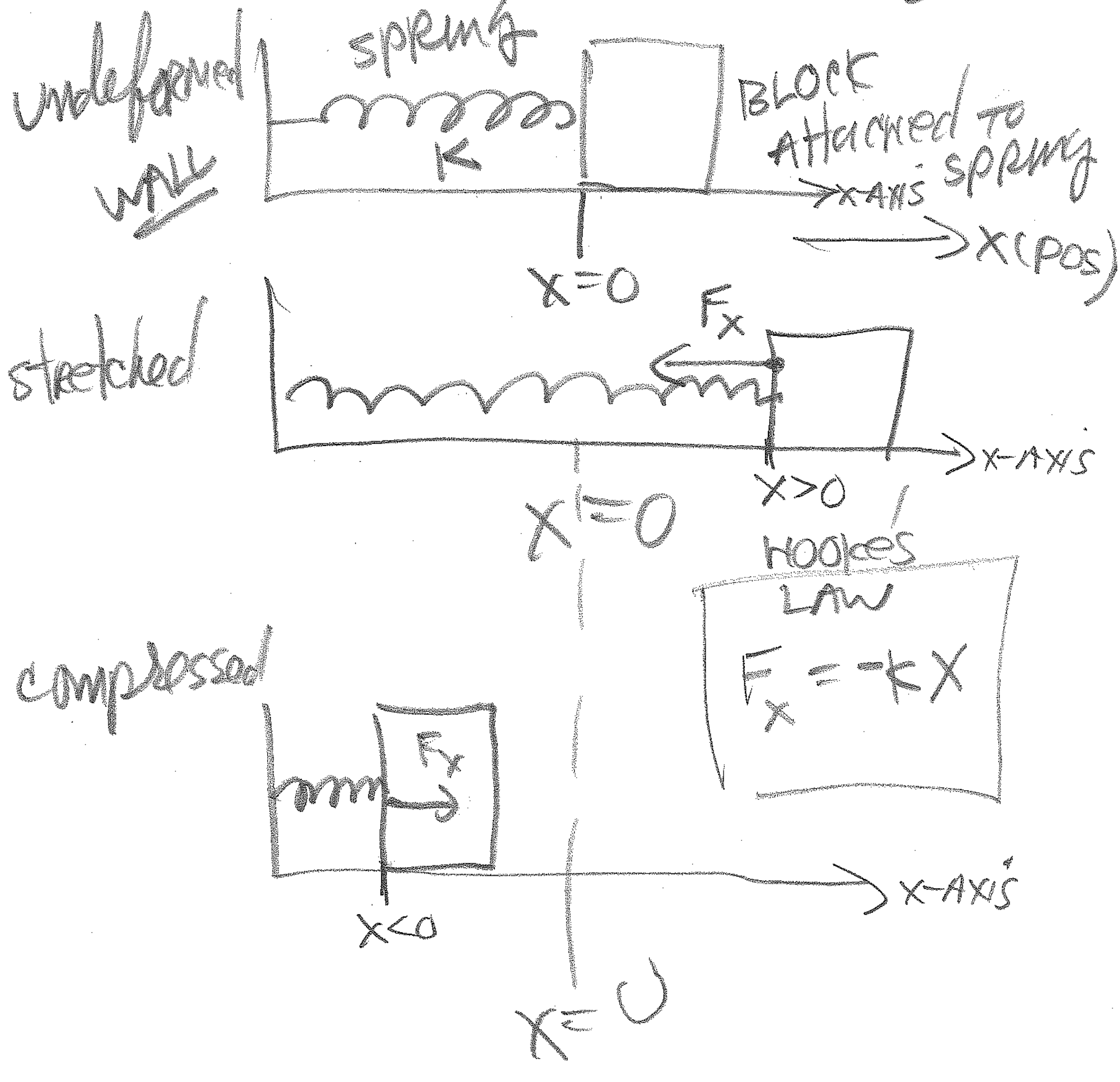
$$F_y = -mg$$

$$dW_g = -mg\,dy$$



$$W_g = -\int_{y_i}^{y_f} mg\,dy = mg(y_i - y_f) = \pm mgh$$

(c) W_S = work of a spring



Hooke's Law

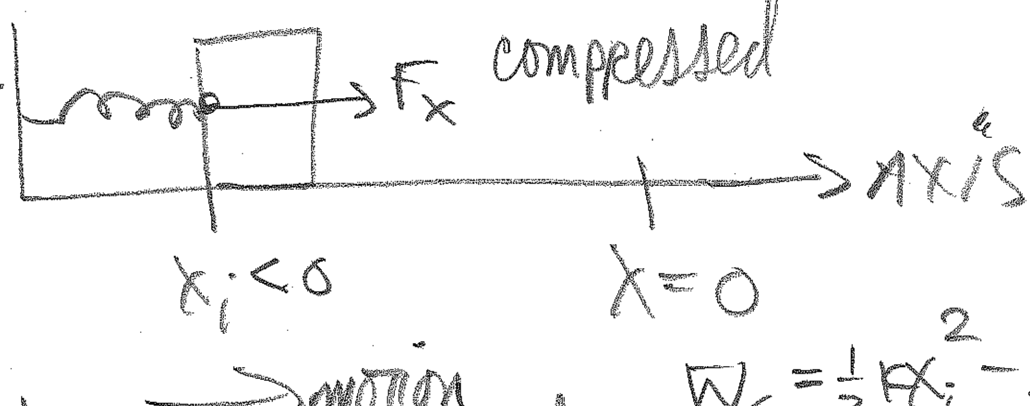
$$F_x = -kx$$

$$d\overline{W}_s = F_x \cdot dx \quad (F_x \neq \text{constant})$$

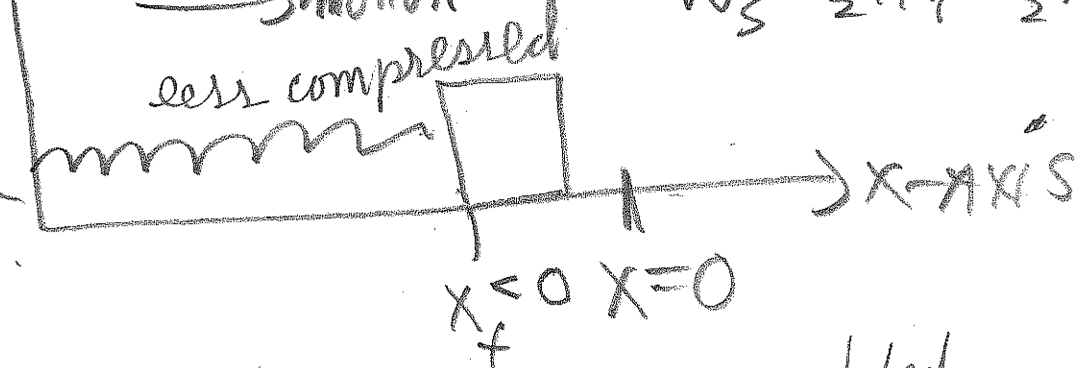
$$d\overline{W}_s = (-kx) \cdot dx$$

$$\overline{W}_s = \int_{x_i}^{x_f} (-kx)\,dx = \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2$$

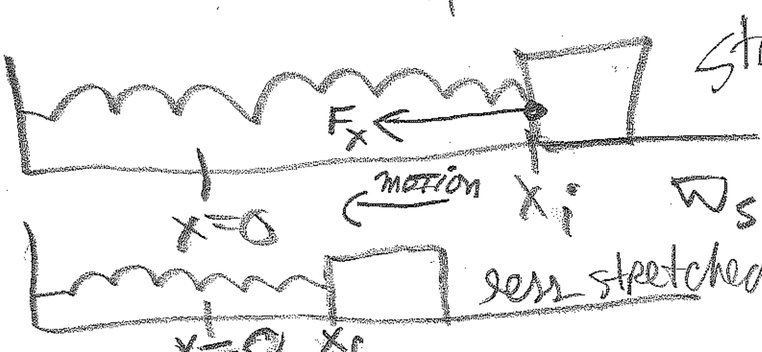
I



$$\overline{W}_s = \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2 > 0$$

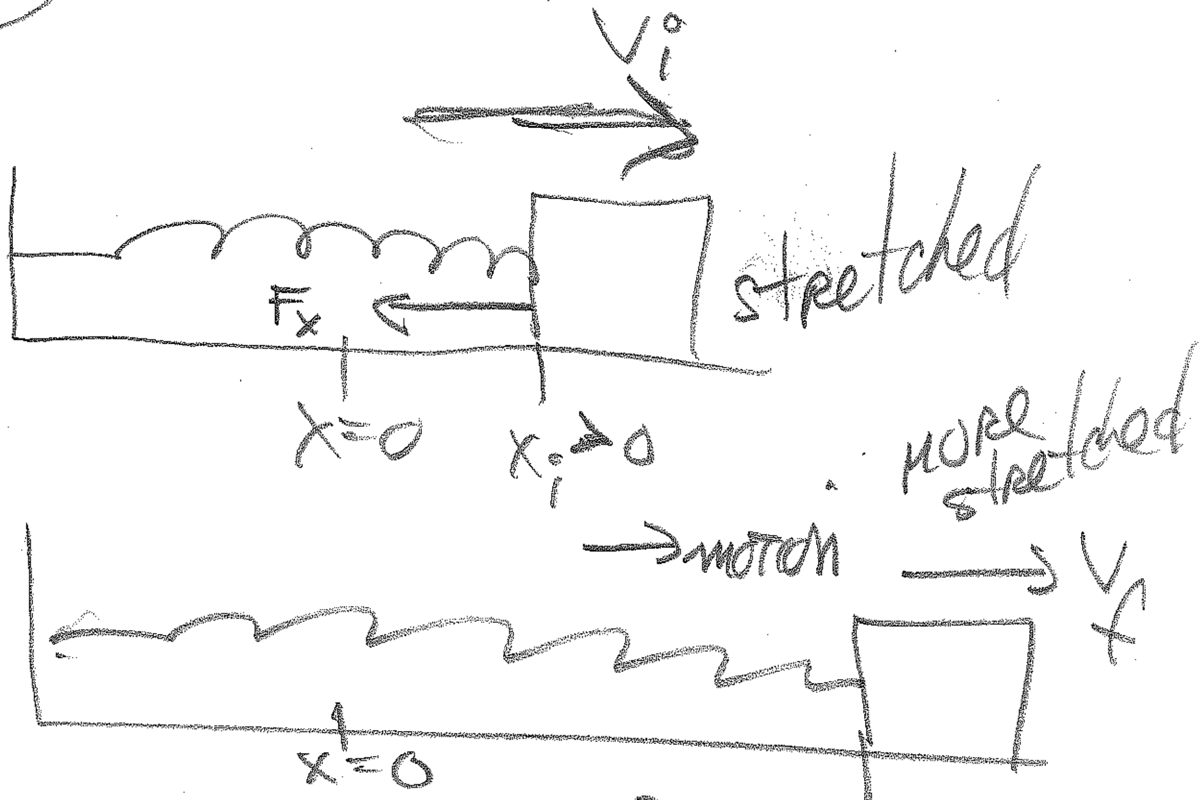


II



$$\overline{W}_s = \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2 > 0$$

III



$W_s < 0$ (PREDICTION)

$$W_s = \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2 < 0$$

since $x_i < x_f$

CH 6

$KE = \frac{1}{2} m v^2$

$W_{net} = \Delta KE$

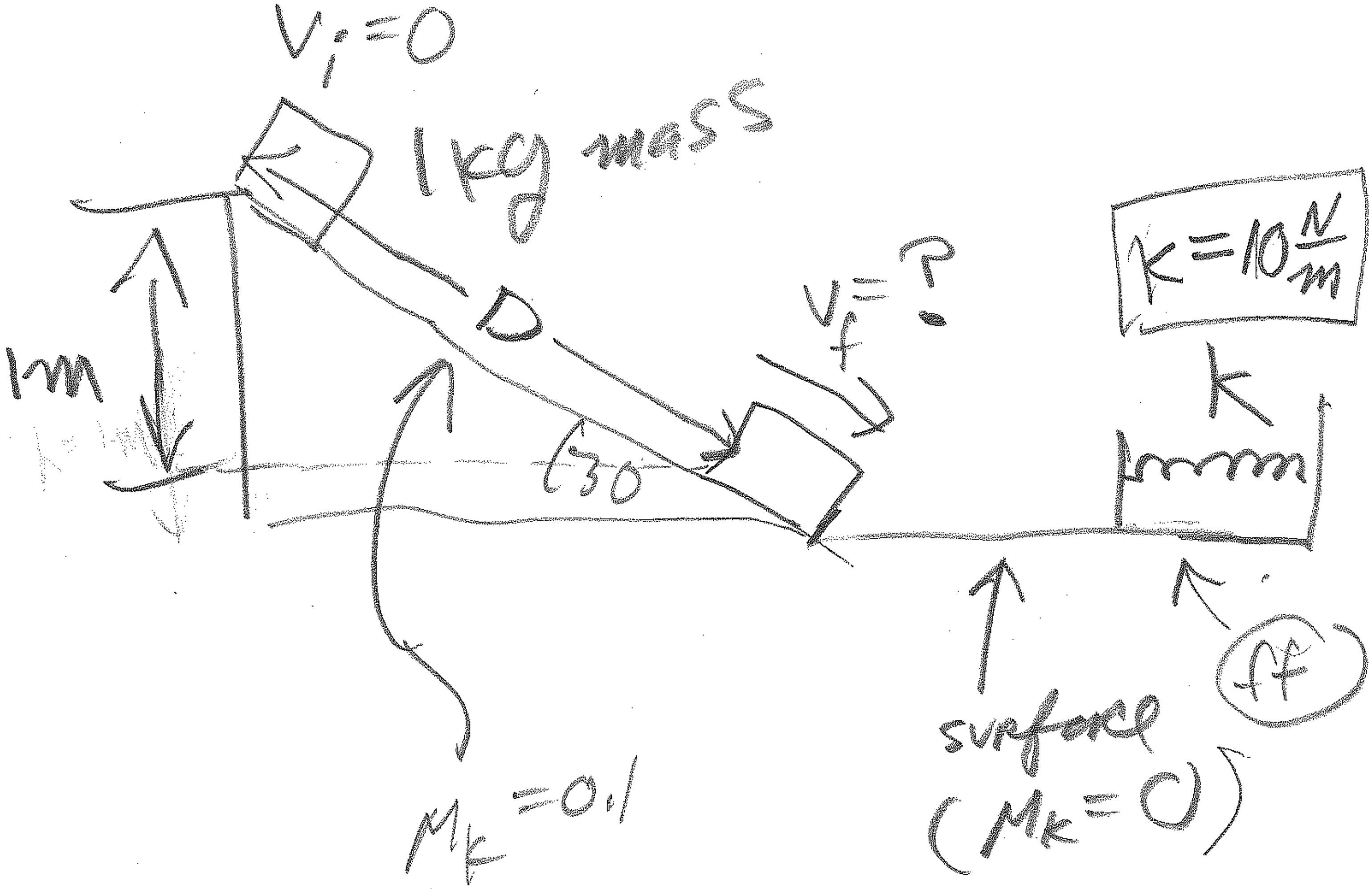
$W_{net} = \sum_{i=1}^{n} W_i$

SUM OVER ALL n FORCES.

$W_g = \pm mgh = mg(y_i - y_f)$

$W_s = \frac{1}{2} k x_i'^2 - \frac{1}{2} k x_f'^2$ *

* use x' to distinguish from x; x' is along spring axis



(a) $V_f = ?$

(b) How far does mass compress spring at maximum compression?

$$L = \frac{h}{\sin 30} = 2\,(m)$$

$$\frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 = W_g + W_{f_k}$$

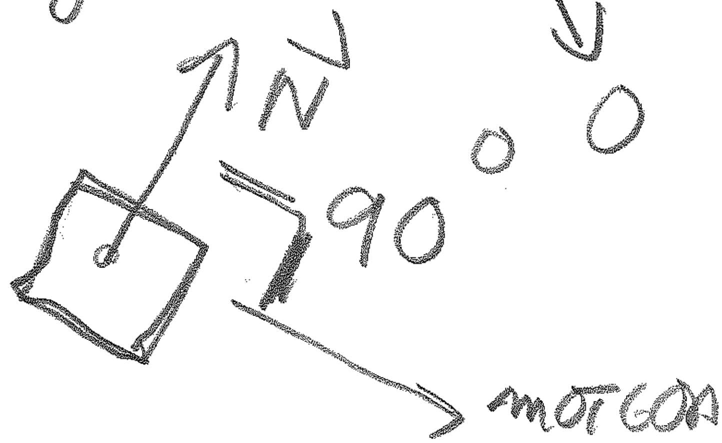
$$0 = +mgh + (-f_k \cdot L)$$

CH5 | $f_k = \mu_k \cdot N$ and CH4 |

$N = mg\cos\theta$

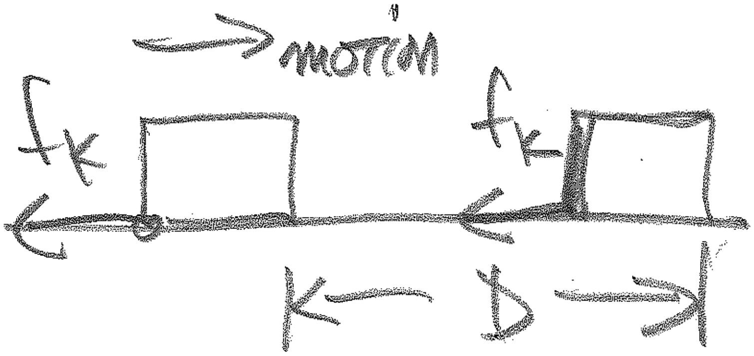
(a) $v_f = ?$ $\quad W_{net} = \sum W = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$

$$\sum_{i \to f} W = W_g + W_{f_k} + \underset{\downarrow \atop 0}{W_N}$$



$$W_N = 0 = N \cdot \cos 90 \cdot L$$
$$= 0$$

Note: $W_{f_k} \le 0 \Leftrightarrow -f_k \cdot D \le 0$



$$W_{f_k} = f_k \cdot \cos 180 \cdot D$$
$$= f_k \cdot (-1) \cdot D$$
$$= -f_k \cdot D$$

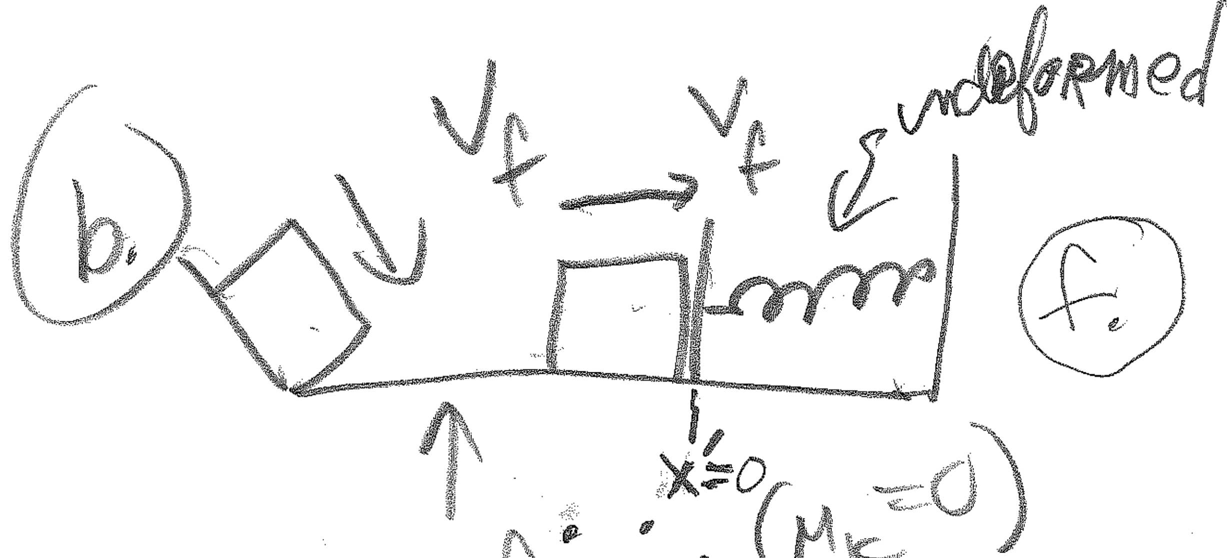
$$\frac{1}{2}mv_f^2 = mgh - \mu_k mg\cos 30 \cdot L$$

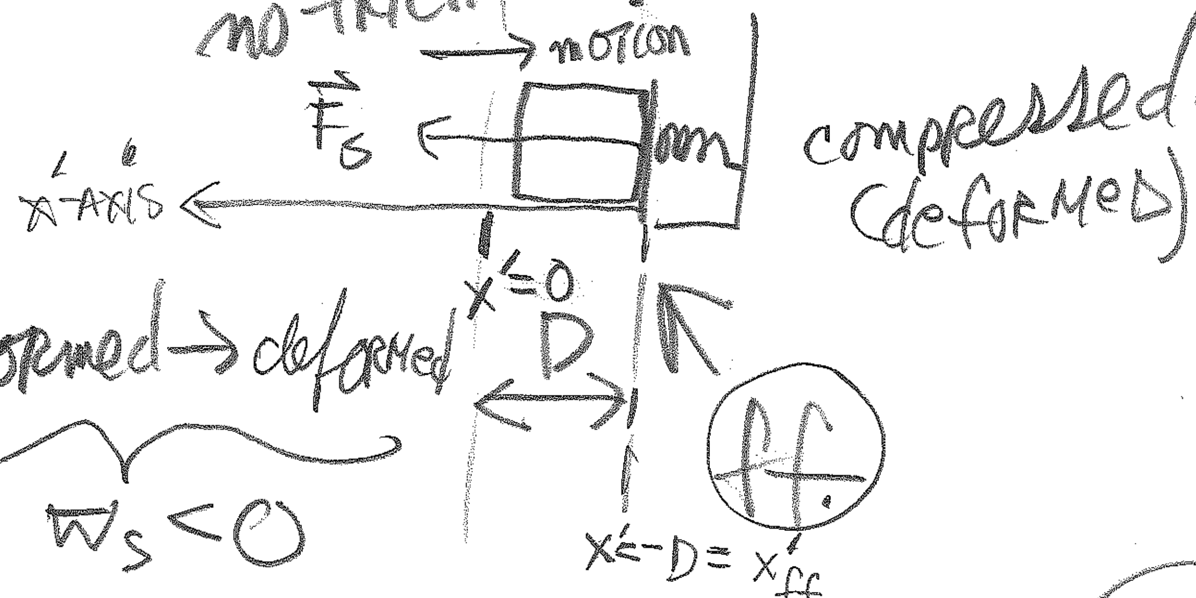
$$\frac{1}{2}(1)v_f^2 = (1)(9.8)(1) - (0.1)(1)(9.8) \cdot 0.867 \cdot (2)$$

$$\frac{v_f^2}{2} = 9.8 - 1.73$$

$$v_f = \sqrt{2(8.07)}$$

$$v_f = 4.0\,\frac{m}{s}$$





$\underbrace{\text{undeformed} \to \text{deformed}}_{W_s < 0}$

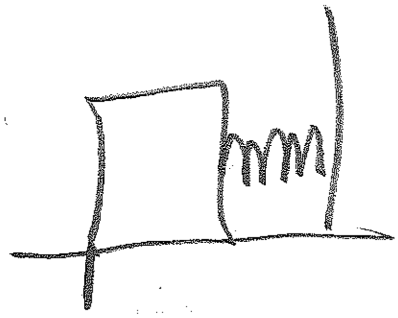
$$\underset{f \to ff}{W_{net}} = W_g + W_N + W_{f_k} + W_s$$

$W_g \to 0$ $(h = 0)$

$W_N \to 0$ $(\vec{N}\ 90^\circ$ motion$)$

$W_{f_k} \to 0$ $(\mu_k = 0)$

$x'_f = 0$



$x'_{ff} = -D$

$$W_s = \frac{1}{2}kx'^2_f - \frac{1}{2}kx'^2_{ff}$$

$$= 0 - \frac{1}{2}kD^2$$

$$\Delta KE_{f \to ff} = W_s$$

$$\frac{1}{2}mv_{ff}^2 - \frac{1}{2}mv_f^2 = -\frac{1}{2}kD^2$$

$$0 - \frac{1}{2}mv_f^2 = -\frac{1}{2}kD^2 \quad \left(k = 10\,\frac{N}{m}\right)$$

$$-\frac{1}{2}(1)V_f^2 = -\frac{1}{2}(10)D^2$$

$$D = \sqrt{\frac{1}{10}} \cdot V_f$$

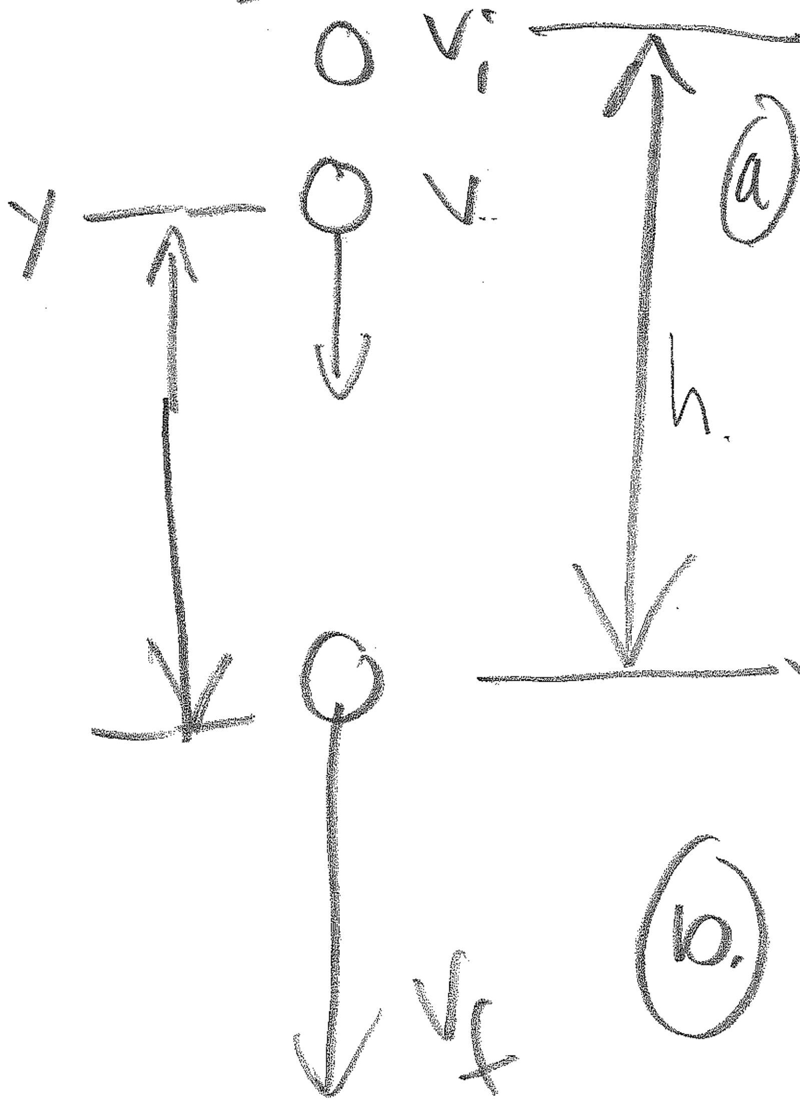
$$D = \sqrt{0.1} \cdot \left(4.0\,\frac{m}{s}\right)$$

$$\doteq (0.3)(4.0)$$

$$= 1.20\ (m)$$

CH 7

ASSUME $v_i = 0$ (from rest)



(a) $W_g = mgh$

$$\frac{1}{2}mv_f^2 = mgh = mg(y_i - y_f)$$

check between y_i and y:

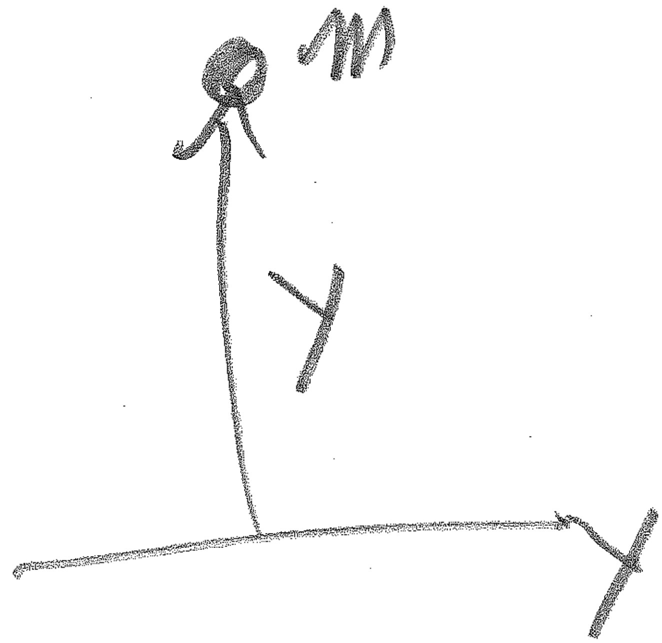
(b) $W_g = mg(y_i - y)$

$$mg(y_i - y) = \frac{1}{2}mv^2$$

$$mgy_i - mgy = \frac{1}{2}mv^2$$

$$mgy_i = \frac{1}{2}mv^2 + mgy$$

NOTE: $KE_i = 0$; $PE_i = KE + PE$

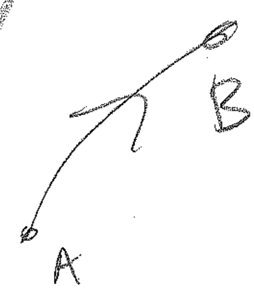


$y = 0$

$$U_g = mgy$$

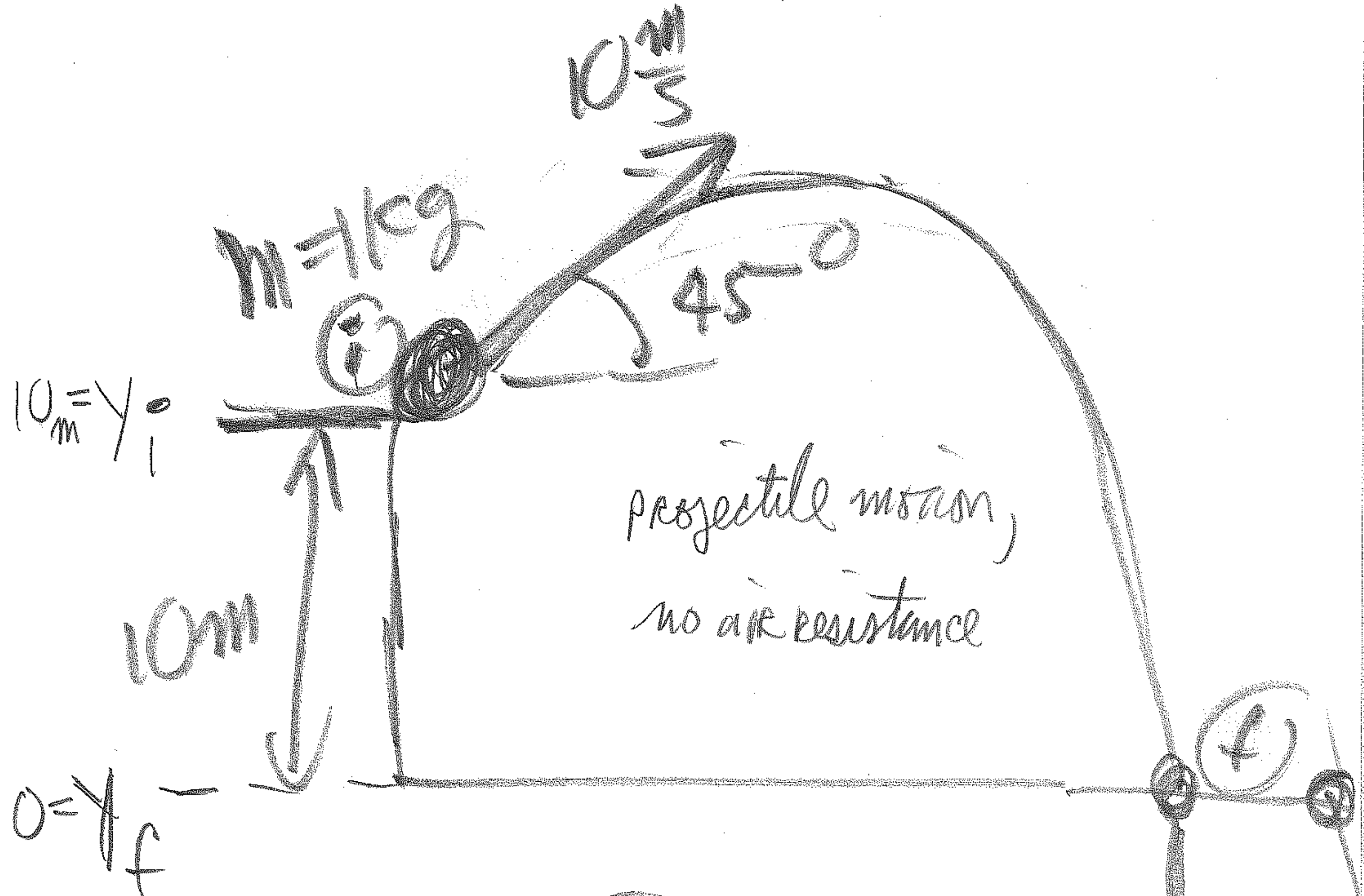
$$PE_g = U_g$$

conservation of Energy
(only gravity)



$$KE_A + U_{Ag} = KE_B + U_{Bg}$$

$$U_g = mgy$$



$$V_f = ?$$

CH3 Difficult

$$KE_i + U_i^{\leftarrow mgy_i} = KE_f + U_f^{\leftarrow mgy_f = 0}$$

V_f

$$\frac{1}{2}(1)10^2 + (1)(9.8)(10) = \frac{1}{2}(1)V_f^2 + 0$$

$$V_f = 17.3 \text{ m/s}$$