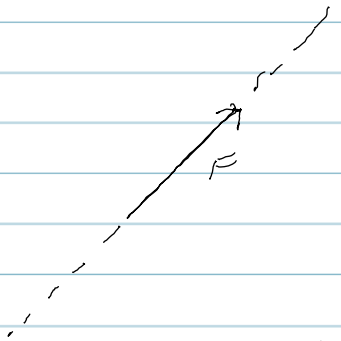
CH 3 — FORCES - EQUILIBRIUM — & FREE-BODY DIAGRAMS

SECTION 3.1

TERMINOLOGY —

LINE OF ACTION —



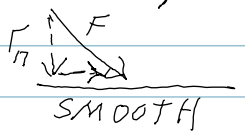
SYSTEM OF FORCE

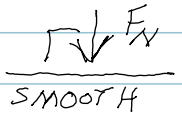
EXTERNAL + INTERNAL FORCE $\Rightarrow \sum F_{EXT} = ma = 0$ (a_0)

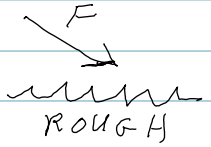
BODY & SURFACE

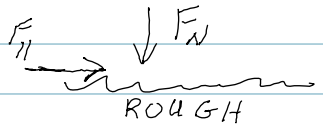
CATEGORIES — 1) CONTACT FORCE 2) FORCE AT A DISTANCE —

SURFACE — SMOOTH, ROUGH

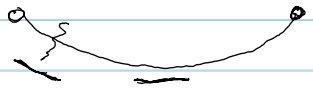




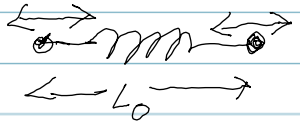




ROPE & CABLES



SPRINGS



$F = -kX$ where $X = \Delta L$
$X = \delta$

EQUILIBRIUM $a_{PARTS} = 0$ $a = \frac{dv}{dt} = \frac{\Delta v}{t}$

v = CONSTANT (STRAIGHT LINE)

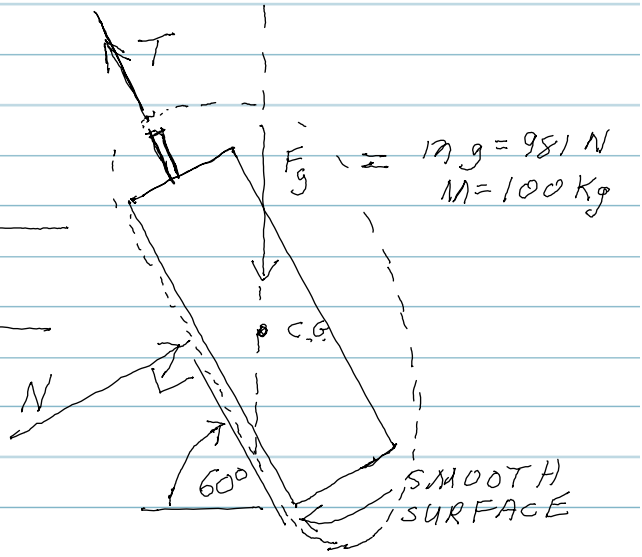
FREE-BODY DIAGRAM — (FBD)

SECTION 3.1 (CONT.)

MEANS TO SHOW "ΣF"

FBD:

1. IDENTIFY "F" NEEDED
2. SKETCH
3) EXTERNAL FORCE



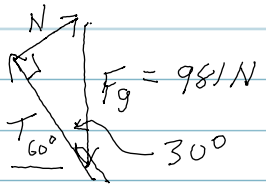
PROBLEM 3-11
GIVEN:

FIND: T = ?

SOLUTION:

$$\cos(\theta) = \frac{A}{H}$$

$$\cos(30^\circ) = \frac{T}{981N}$$



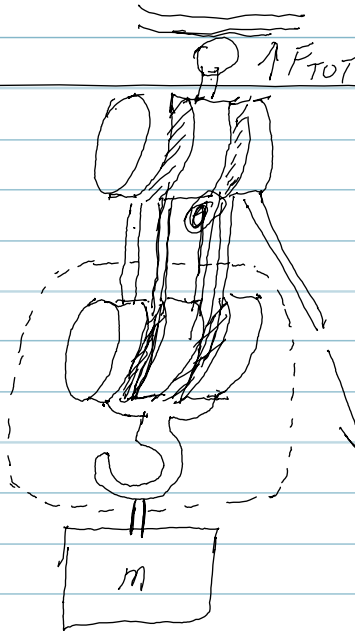
$$T = 981 \cos(30^\circ)$$

$$T = 850\ N$$

ANOTHER FBD EXAMPLE -

A BLOCK AND TACKLE FOR LIFTING MECHANICAL ADVANTAGE

$$MA = \frac{F_{OUTPUT}}{F_{INPUT}} = \frac{4}{1} = 4$$



$F_g = 4T$

$\Sigma F = +4T - F_g = 0$

SECTION 3.3 THREE-DIMENSIONAL FORCES

$\Sigma F = ma \Rightarrow F_x = ma_x,\ F_y = ma_y,\ F_z = ma_z$ ($a_z = 0$)

$\Sigma F_x = 0 \Rightarrow$

$\Sigma F_y = 0 \Rightarrow$

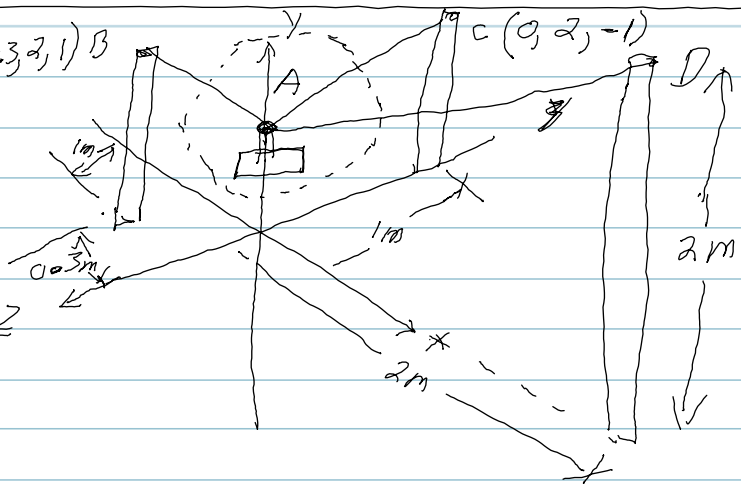
$\Sigma F_z = 0 \Rightarrow$

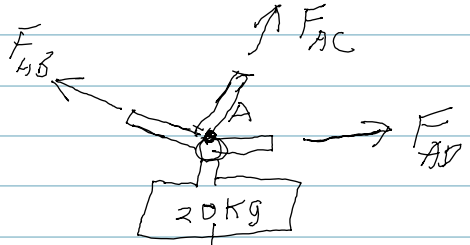
PROBLEM 3-69 B(−3, 2, 1) C(0, 2, −1) D(2, 2, 0)

GIVEN: $m = 20\,kg$

$A = (0, 1.2m, 0)$

FIND: F_{AB}, F_{AC}, F_{AD}





$F_g = mg = -196N\,j$

$F_g = 0i - 196j + 0k$

SOLUTION: 1) $r_{AB} = ?$

$r_b = -3i + 2j + 1k$

$-r_a = -[0i + 1.2j + 0k]$

$r_{ab} = -3i + 0.8j + 1k$

$|r_{ab}| = \sqrt{(-3)^2 + .8^2 + 1^2} = \sqrt{1.73}$

$|r_{ab}| = 1.315$

$e_{ab} = \frac{r_{ab}}{|r_{ab}|} = -0.228i + 0.608j + .760$

(CONT.)

PROB 3-69 (CONT.)

$e_{AC} = 0i + 0.625j - 0.781k$

$e_{AD} = 0.928i + 0.371j + 0k$

$F = |F| e_{\_}$

$F_{AB} = |F_{AB}| e_{AB} = |F_{AB}| [-0.228i + 0.608j + 0.760k]$

ALL FORCES

$F_{AB} = -0.228|F_{AB}|\,i + .608|F_{AB}|\,j + .760|F_{AB}|\,k$

$F_{AC} = +0|F_{AC}|\,i + .625|F_{AC}|\,j - .781|F_{AC}|\,k$

$F_{AD} = 0.928|F_{AD}|\,i + .371|F_{AD}|\,j + 0|F_{AD}|\,k$

$+ \quad F_g = 0i - 196.j + 0k$

$\Sigma F = 0i + 0j + 0k$

$\Sigma F_x = 0 \Rightarrow (1) \quad -.228|F_{AB}| + .928|F_{AD}| = 0$

$\Sigma F_y = 0 \Rightarrow (2) \quad .608|F_{AB}| + .625|F_{AC}| + .371|F_{AD}| - 196 = 0$

$\Sigma F_z = 0 \Rightarrow (3) \quad .760|F_{AB}| - .781 F_{AC} = 0$

(1) SOLVE $|F_{AB}| = -\dfrac{.928|F_{AD}|}{.228}$

(2)(3) 2 EQ + 2 UNK $\Rightarrow F_{AD} + F_{AC}$

$|F_{AB}| = \underline{150\ N}$

$|F_{AC}| = \underline{146\ N}$

$|F_{AD}| = \underline{37\ N}$