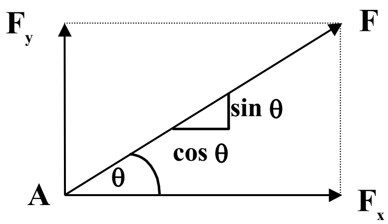
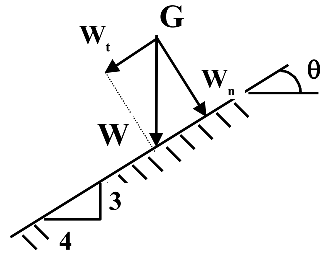
REFERENCE DATA CARD
EGM 3420C
PART A: STATICS

I. Resolving a Force into Orthogonal Components:

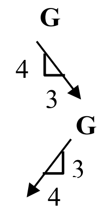




$$F_x = F\cos\theta$$
$$F_y = F\sin\theta$$

$$W_n = W_\perp = W\cos\theta = \frac{4}{5}W$$

$$W_t = W_\parallel = W\sin\theta = \frac{3}{5}W$$



II. 2-D Equilibrium:

$$\sum \underline{F} = 0 \text{ and } \sum \underline{M}_O = 0$$

$$\sum \underline{F}_x = 0 \quad \sum \underline{F}_y = 0 \quad \sum \underline{M}_O = 0$$

III. Centroid of an Area

SHAPE	A	$\tilde{x}$	$M_y = \tilde{x}A$	$\tilde{y}$	$M_x = \tilde{y}A$

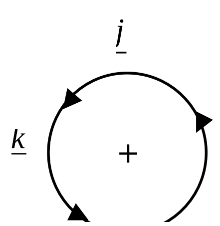
$$\bar{x} = \frac{\sum M_y}{\sum A} = \frac{\sum \tilde{x}A}{\sum A} \qquad \bar{y} = \frac{\sum M_x}{\sum A} = \frac{\sum \tilde{y}A}{\sum A}$$

IV. 3D Equilibrium

$$\sum \underline{F} = 0 \text{ and } \sum \underline{M}_O = 0$$

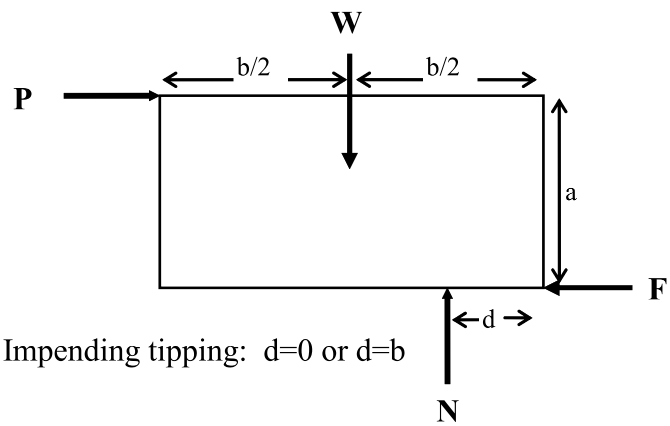
$$\underline{F}_{AB} = F_{AB}\underline{u}_{AB} = F_{AB}\frac{\underline{AB}}{|\underline{AB}|} = F\left(\frac{\underline{r}}{|\underline{r}|}\right)$$

$$\underline{M}_O = \underline{r}_{A/O} \times \underline{F}_A = \begin{vmatrix} \underline{i} & \underline{j} & \underline{k} \\ r_x & r_y & r_z \\ F_x & F_y & F_z \end{vmatrix}$$

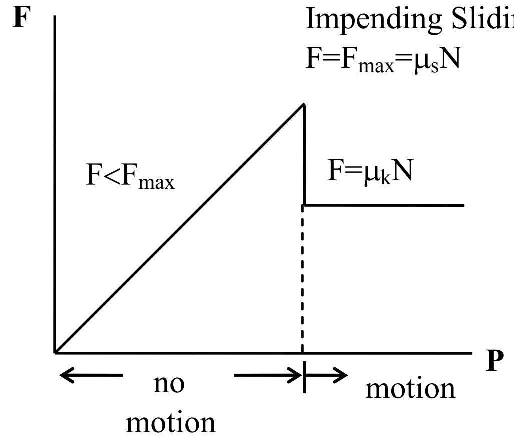


FORCES, MOMENTS, REACTIONS	$\underline{r}_{\text{F/PT}}$	$\underline{F}$	$\underline{r} \times \underline{F}$ +Couples+ Moment Reactions

V. Friction

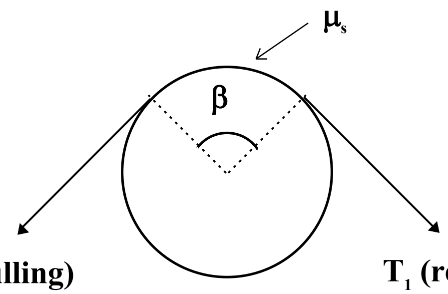


Impending tipping: d=0 or d=b



VI. Belt Friction: (flat belt, impending motion)

Fixed Cylindrical Drum



$$\frac{T_2}{T_1} = e^{\mu_s \beta} \quad (\beta \text{ in radians})$$

VII. CABLES

Point Loads:

$$A_x = T_1 \cos\theta_1 = T_2 \cos\theta_2 = T_3 \cos\theta_3 = T_i \cos\theta_i = B_x$$

$$T_{max} = (A_x^2 + A_y^2)^{1/2} \text{ or } T_{max} = (B_x^2 + B_y^2)^{1/2}$$

Uniformly Distributed Horizontal Loads (Supports at Same Elevation)

$$F_H = \frac{W_o L^2}{8h} \qquad T_{max} = \frac{w_o L}{2}\sqrt{1+\left(\frac{L}{4h}\right)^2} \qquad L_{total} = \frac{L}{2}\left[\sqrt{1+\left(\frac{4h}{L}\right)^2} + \frac{L}{4h}\sinh^{-1}\left(\frac{4h}{L}\right)\right]$$

PART B. DYNAMICS

VIII. Particle Kinematics.

Rectangular components

$$\underline{r} = x\underline{i} + y\underline{j}$$

$$\underline{v} = \frac{d\underline{r}}{dt} = \frac{dx}{dt}\underline{i} + \frac{dy}{dt}\underline{j}$$

$$\underline{a} = \frac{d\underline{v}}{dt} = \frac{d^2\underline{r}}{dt^2} = \frac{d^2x}{dt^2}\underline{i} + \frac{d^2y}{dt^2}\underline{j}$$

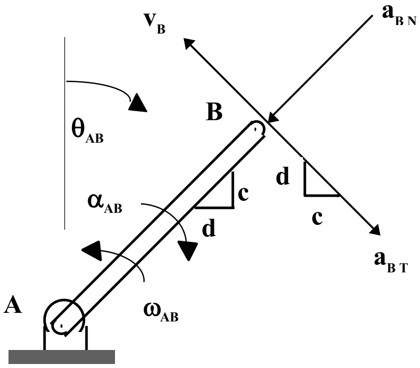
Tangential & normal components

$s =$ *position along path*

$$\underline{v} = \frac{ds}{dt}\underline{u}_T = v\underline{u}_T$$

$$\underline{a} = \frac{d\underline{v}}{dt} = \frac{dv}{dt}\underline{u}_T + \frac{v^2}{\rho}\underline{u}_N$$

IX. Rotation About a Fixed Axis or Fixed Point



SCALAR NOTATION	VECTOR NOTATION
$s_B = \theta_{AB} r_{B/A}$	
$v_B = \omega_{AB} r_{B/A}$	$\underline{v}_B = \underline{\omega}_{AB} \times \underline{r}_{B/A}$
$a_{B_T} = \alpha_{AB} r_{B/A}$	$\underline{a}_{B_T} = \underline{\alpha}_{AB} \times \underline{r}_{B/A}$
$a_{B_N} = \omega_{AB}^2 r_{B/A}$	$\underline{a}_{B_N} = \underline{\omega}_{AB} \times (\underline{\omega}_{AB} \times \underline{r}_{B/A})$

$\underline{r}_{B/A} \equiv$ position of B wrt A as if A were fixed

X. GENERAL PLANE MOTION

$$\underline{v}_A = \underline{v}_B + \underline{v}_{A/B} \qquad or \qquad \underline{v}_A = \underline{\omega}_{AB} \times \underline{r}_{A/IC_{AB}}$$

$$\underline{a}_A = \underline{a}_B + \underline{a}_{A/B}$$

XI. ROLLING WHEEL ON FLAT STATIONARY SURFACE

(assuming point O is the geometric center of the wheel)

NO SLIP	SLIPPING
$s_o = \theta r$	$s_o \neq \theta r$
$v_o = \omega r$	$v_o \neq \omega r$
$a_o = \alpha r$	$a_o \neq \alpha r$
$v_{contact\ point} = 0$	$v_{contact\ point} \neq 0$
$F < F_{max}$	$F = \mu_k N$

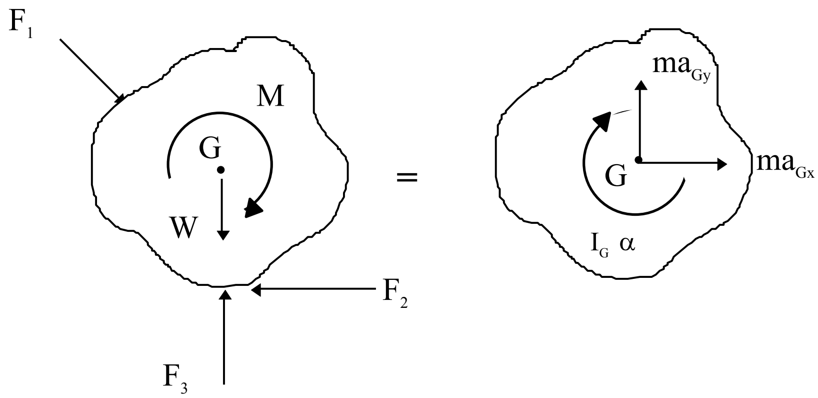
XII. MASS MOMENT OF INERTIA FOR COMPOSITE BODY:

Shape	Mass(m)	$\bar{x}$	$\bar{x}m$	$\bar{y}$	$\bar{y}m$	I_G	md^2	$I_G + md^2$

$$\bar{x}_G = \frac{\sum \bar{x}m}{\sum m} \qquad \bar{y}_G = \frac{\sum \bar{y}m}{\sum m} \qquad I = \sum\left(I_G + md^2\right)$$

XIII. FORCE ACCELERATION METHOD

FBD = KD



$$\Sigma F_x = ma_{Gx} \qquad \Sigma F_y = ma_{Gy} \qquad \Sigma M_G = I_G\alpha$$

XIV. WORK-ENERGY

$$T_1 + \sum U_{1\to 2} = T_2$$

$$\sum \frac{1}{2} m v_{G1}^2 + \sum \frac{1}{2} I_G \omega_1^2 + \sum \left\{ \int_{s_1}^{s_2} \underline{F} \bullet d\underline{s} \right\} + \sum \left\{ \int_{\theta_1}^{\theta_2} \underline{M} \bullet d\underline{\theta} \right\} = \sum \frac{1}{2} m v_{G2}^2 + \sum \frac{1}{2} I_G \omega_2^2$$

$$U_W = \pm W \Delta y$$

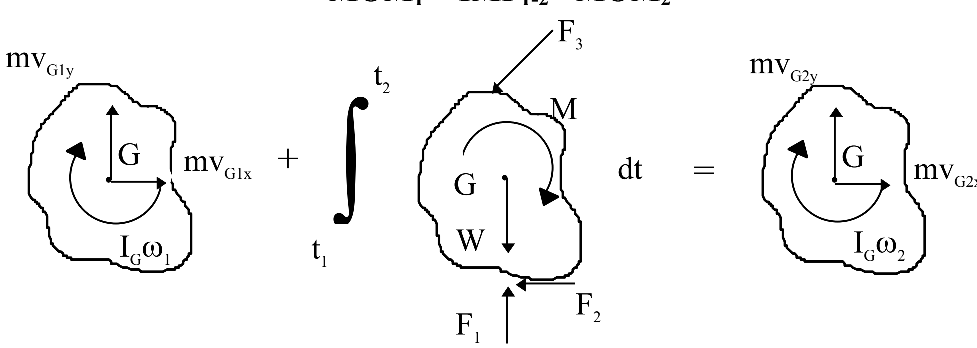
$$U_{FR} = -F_{FR} d = -\mu_K N d$$

$$U_{SPRING} = -\frac{1}{2} k (s_2^2 - s_1^2) \qquad s_2 = l_2 - l_0$$

$$s_1 = l_1 - l_0$$

XV. IMPULSE-MOMENTUM METHOD

$$\mathbf{MOM_1 + IMP_{1\text{-}2} = MOM_2}$$



$$mv_{G1x} + \int_{t1}^{t2} \sum F_x dt = mv_{G2x}$$

$$mv_{G1y} + \int_{t1}^{t2} \sum F_y dt = mv_{G2y}$$

$$I_G \omega_1 + \int_{t1}^{t2} \sum M_G dt = I_G \omega_2$$