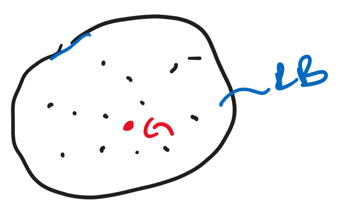
5.3 Work Energy for Rigid Bodies (p. 325)



$T_1 + U_{1-2} = T_2$

$U_{1-2} \to U^{C}_{1-2},\ U^{NC}_{1-2}$

$U^{C}_{1-2} \to V_g,\ V_{sp}$

$$T_1 + V_1 + U^{NC}_{1-2} = T_2 + V_2$$

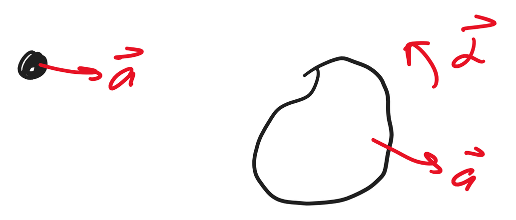
For more than 1 RB / particles

$$\sum_{i=1}^{n} T_{1,i} + \sum_{i=1}^{n} V_{1,i} + U^{NC}_{1-2} = \sum_{i=1}^{n} T_{2,i} + \sum_{i=1}^{n} V_{2,i}$$

n = # of RB's / particles

For Rigid Bodies:

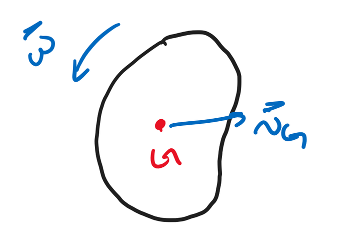
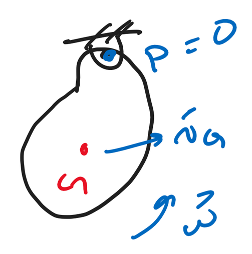
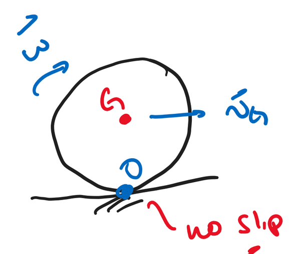
- Kinetic energy (p. 326, 329)



$$T = \frac{1}{2} m v_P^2 + \frac{1}{2} I_P \omega^2 + m\vec{v}_P \cdot (\vec{\omega} \times \vec{r}_{G/P})$$

↳ For any point P

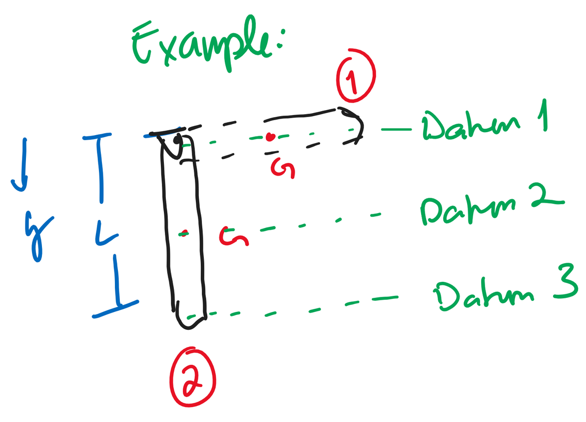
find P → $v_P = 0$, $\vec{r}_{G/P} = 0$

Point P	Situation	T
$\vec{r}_{G/P} \to P = G$		ω^2
$P \to v_P = 0$		$T = \frac{1}{2} I_O \omega^2$ fixed point
	 no slip $\vec{v}_O = 0$ $\vec{a}_O \neq 0$	$T = \frac{1}{2} I_O \omega^2$ no slip point $T = \frac{1}{2} m v_G^2 + \frac{1}{2} I_G \omega^2$ $= \cancel{\frac{1}{2} m v_O^2} + \frac{1}{2} I_O \omega^2$

- Potential Energy (Gravity)
  - Free to select any datum
  - change in vertical position of the center of mass G.

  $V_g = mgh$

Example:



	$V_{1,g}$	$V_{2,g}$
Dat 1	0	$mg(-\frac{L}{2})$
Dat 2	$mg(\frac{L}{2})$	0
Dat 3	$mg(L)$	$mg(\frac{L}{2})$

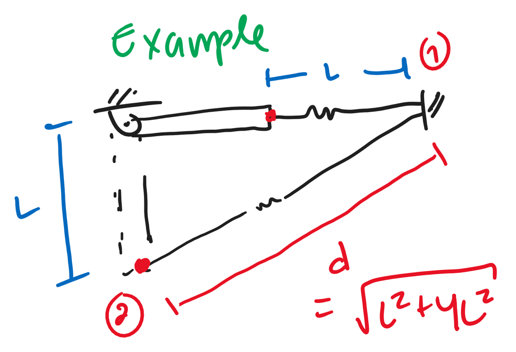
→ $\Delta V = mg\frac{L}{2}$

- Potential Energy (Elastic)

  $V_{sp} = \frac{1}{2} k (L - L_0)^2$, L_0 = unstretched length

  - Follow the displacement of the attachment point to the spring $\frac{1}{2} m v_G^2 + \frac{1}{2} I_G$

Example

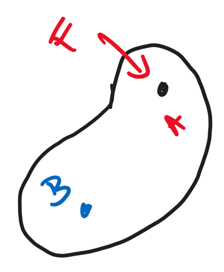


$V_{1,sp} = \frac{1}{2} k (L - L_0)^2$, $L = L_0$

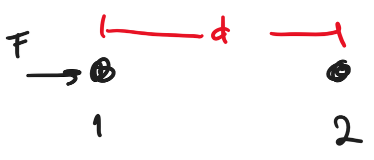
$= 0$

$V_{2,sp} = \frac{1}{2} k (d - L_0)^2$, $d = \sqrt{L^2 + 4L^2}$

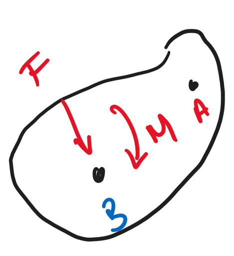
- Non-conservative work (p. 327)
  - Depend on where the applied non-conservative forces are acting



Let's say force F is applied at A, but I only know the motion of B



$U^{NC}_{1-2} = Fd$

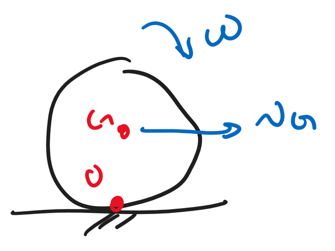


$$U^{NC}_{1-2} = \int_{s_1}^{s_2} F_t\, ds \quad \text{(For point A)}$$

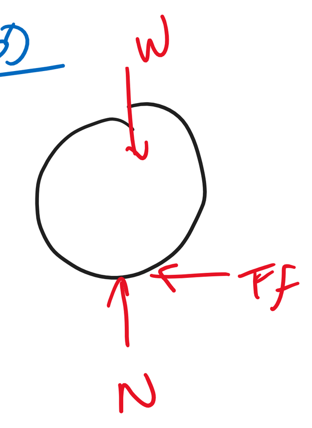
equivalent

$$U^{NC}_{1-2} = \int_{s_1}^{s_2} F_t\, ds + \int_{\theta_1}^{\theta_2} M\, d\theta \quad \text{(For point B)}$$

Note: Friction for rolling w/o slip



FBD



Any NC forces doing work?

NC: F_f, N

N → does not do work (neve) bc it's ⊥ to the path

F_f → does not do work because $v_O = 0$, it acts on a stationary point.