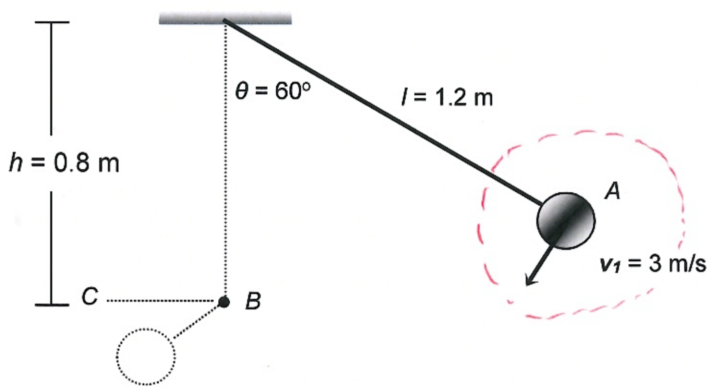
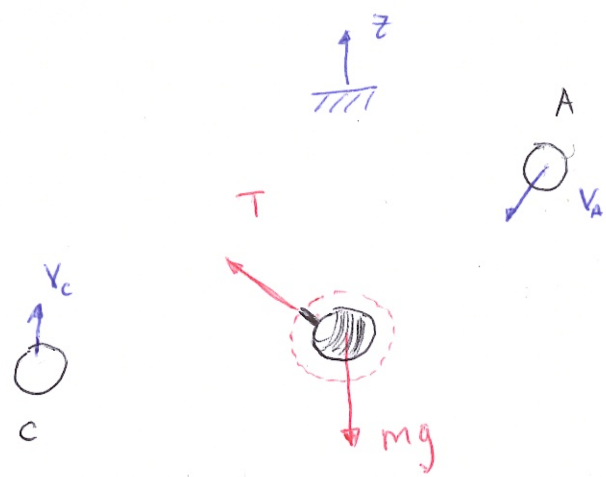
ROSE-HULMAN Institute of Technology
Sophomore Engineering Curriculum

Example

A bowling ball is released from position A with an initial velocity of 3 m/s. The ball swings in a vertical plane. At the bottom position, the cord strikes the fixed bar at B, and continues to swing. Calculate the velocity of the ball as it passes position C.





Work-energy from A to C

$$KE_C - KE_A + PE_C - PE_A = \cancel{W_{IN,AC}} \rightarrow 0$$

T always ⊥ to $\vec{s}$ & gravity doesn't do work. (only surface forces can do work.)

$$\frac{1}{2}\cancel{m}V_C^2 - \frac{1}{2}\cancel{m}V_A^2 + \cancel{m}g(Z_C) - \cancel{m}g(Z_A) = 0$$

$$V_C = \left[2g(Z_A - Z_C) + V_A^2\right]^{1/2}$$

Let ceiling be $Z = 0$:

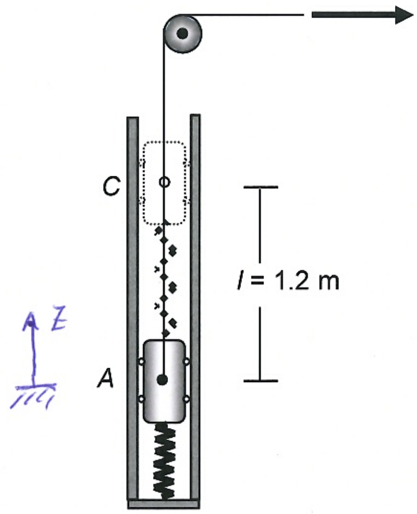
$$= \left[(2)(9.81\ \tfrac{m}{s^2})\left((-1.2\,m)\cos 60^\circ - (-0.8\,m)\right) + 3^2\ m^2/s^2\right]^{1/2}$$

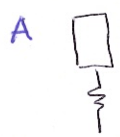
$$= \boxed{3.60\ m/s}$$

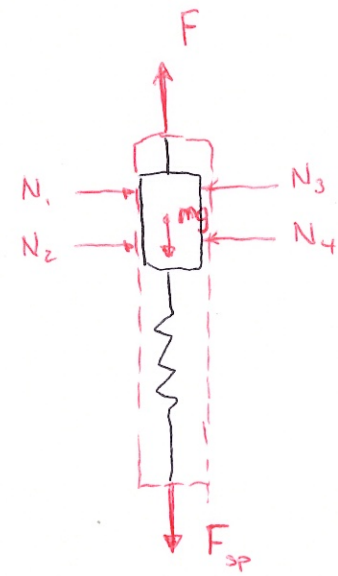
Example

A 10-kg slider is originally at rest in position *A* where the spring is stretched a distance of 0.6 m. (The attached spring has a stiffness [i.e., *k*] of 60 N/m.) A constant 250-N force is then applied to the pulley and the slider moves with negligible friction in the cylinder as shown. Calculate the velocity of the slider as it passes point *C*.

Put spring inside system.







Work-energy A → C

$$\underbrace{E_{sp,C} - E_{sp,A}}_{\text{New!}} + KE_C - KE_A + PE_C - PE_A = W_{AC}$$

≠0!

$$\frac{1}{2}kx_C^2 - \frac{1}{2}kx_A^2 + \frac{1}{2}mV_C^2 - \frac{1}{2}m(\underbrace{V_A}_{\to 0})^2 + mgZ_C - mg\underbrace{Z_A}_{\to 0} = F\cdot l$$

$$V_C = \left[\frac{2F\cdot l}{m} - \frac{2\cancel{m}gZ_C}{\cancel{m}} + \frac{kx_A^2}{m} - \frac{kx_C^2}{m}\right]^{1/2}$$

$$= \left[\frac{2\cdot 250\ N\cdot 1.2m}{10\cdot kg} - (2)(9.81\ \tfrac{m}{s^2})(1.2\ m)\left(\frac{N\cdot m}{m^2/s^2}\right) + \frac{60\ N/m\ (0.6)^2 m^2}{10\ kg} - \frac{60\frac{N}{m}(1.2+0.6)^2 m^2}{10\ kg}\right]^{1/2}$$

$= \boxed{4.38 \text{ m/s}}$