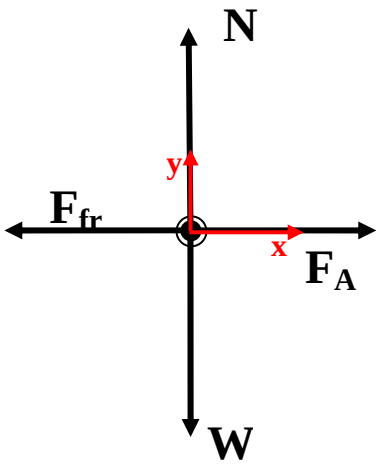
Physics 151 Class Exercise: NonConservative Forces

1. Potsy drags a crate of mass m across a rough floor with a coefficient of kinetic friction of μ_k. If the crate is initially at rest and he applies a force of F_A horizontally over a distance x, derive an algebraic expression for the final velocity of crate by both a dynamics and work-energy approach.

Dynamics (Create a FBD, calculate the acceleration from the summation of forces, and apply kinematics.)



$$\Sigma F_y = N - mg = 0$$

$$N = mg$$

$$\Sigma F_x = F_A - F_{fr} = ma_x$$

$$F_A - \mu mg = ma_x$$

$$a_x = \frac{F_A - \mu mg}{m}$$

Known:	Solve:	Not Involved:
a,x,v_0	v	t

$$v^2 = v_0^2 + 2ax$$

$$v = \sqrt{2ax}$$

$$v = \sqrt{2x\left(\frac{F_A - \mu mg}{m}\right)}$$

Work-Energy – Calculate the Net Work done and apply the work-energy theorem.

$$W_{F_A} = F_A x$$

$$W_{F_{fr}} = -\mu mgx$$

$$W_{Net} = F_A x - \mu mgx$$

Use the Work Energy Theorem – the net work is equal to the change in kinetic energy.

$$W_{Net} = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2 = \frac{1}{2}mv^2$$

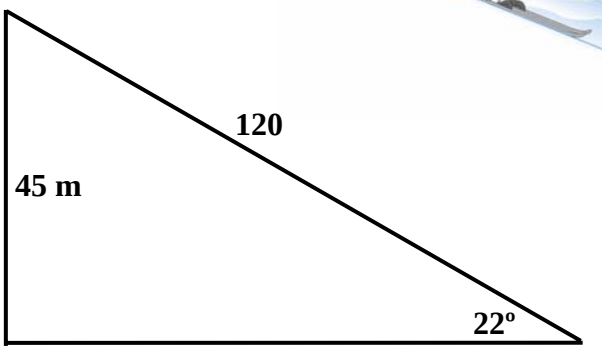
$$F_A x - \mu mgx = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2x\left(F_A - \mu mg\right)}{m}}$$

2. An 80 kg skier starts from rest and travels down the hill shown a distance of 120 m. The slope is inclined at an angle of 22º.

(a) What is the total change in gravitational potential energy?

Let's place the ZLP at the bottom of the hill.



$$\Delta PE = mgh_f - mgh_i = -mgh_i$$

$$= -(80kg)\left(9.81\frac{m}{s^2}\right)(45m) = -35,316 \approx -35,000J$$

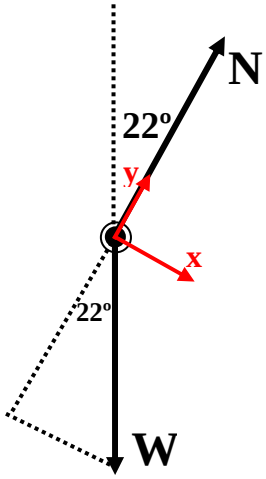
(b) The skier has a velocity of 27.4 m/s at the bottom of the hill. What is his total kinetic energy?

$$KE = \frac{1}{2}mv^2 = \frac{1}{2}(80kg)\left(27.4\frac{m}{s}\right)^2 = 30,030J \approx 30,000J$$

(c) What is the work done by friction?

$$W_{NC} = \Delta PE + \Delta KE$$
$$= PE_f - PE_i + KE_f - KE_i$$
$$= -PE_i + KE_f$$
$$= -35,316J + 30,030J = -5,286 \approx -5,300J$$

(d) Use this to determine the coefficient of kinetic friction for the skies/slope interface.



$$\Sigma F_y = N - mg\cos\theta = 0$$
$$N = mg\cos\theta$$
$$W_{F_{fr}} = -(\mu mg\cos\theta)d$$
$$\mu = \frac{W_{F_{fr}}}{-(mg\cos\theta)d} = \frac{-5,300J}{-(80kg)\left(9.81\frac{m}{s^2}\right)\cos 22°(120m)} = 0.06$$