Ph1a - Flipped Section

Problem Set 6

October 24, 2019

1. Shot Put

Alice and Bob are competing in shot put. They apply different forces to the 4 kg shot put over the length of their arms, which is $l = 1$ m. Alice applies a constant force $F_A = 20$ N. Bob applies a force that increases linearly from 0 to 30 Newtons for the first 0.5 m, and then decreases linearly from 30 to 0 Newtons in the next 0.5 m.

What velocity does each person's shot put have after the forces are applied? Neglect gravity and air resistance.

2. "Power" as you slide!

A box of mass m slides down a rough slope from a height h to the ground at a constant velocity v. The angle that the slope makes with the ground is θ.

a. Calculate the work done on the block by the friction force using $W = \int_A^B \mathbf{F} \cdot d\mathbf{r}$.

b. What is the change in energy of the block?

c. Can you write down a potential energy function ($U(x)$ such that $F(x) = -\frac{dU}{dx}$) corresponding to the friction force? Why or why not?

d. How much power is being dissipated by the friction force as heat?

3. Sledge Sliders

A sled of mass m is given a kick on a frozen pond, imparting to it an initial speed $v_i = 2.0$ m/s. The coefficient of kinetic friction between the ice and the sled is $\mu_k = 0.10$. Use energy considerations to find the distance the sled moves before stopping.

4. Oscillatory Motion

A particle of mass m moves along a trajectory given by $x(t) = x_0 \cos \omega_1 t$, $y(t) = y_0 \sin \omega_2 t$.

a. Find the x and y components of the force.

b. Calculate the work done on the block from $t = 0$ to $t = t'$ using $W = \int_A^B \mathbf{F} \cdot d\mathbf{r}$.

c. Find the potential energy of the particle as a function of x and y. What is the difference in potential energy between $t = 0$ and $t = t'$? Compare the answer to the expression for work done on the block from part (b).

d. Determine the kinetic energy of the particle. Show that the total energy of the particle is conserved.

Some useful formulae:

$$E = \frac{1}{2}mv^2 + U$$

$$F = -dU/dx$$

$$\sin 2\theta = 2\sin\theta\cos\theta$$

$$\cos 2\theta = 1 - 2\sin^2\theta = 2\cos^2\theta - 1$$