Phys 111: Lecture 12

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“The 12^{th} Day: 2 Blue and 2 Green”

Homework Wk #6 Due Today

Today’s Topics

1. Power
2. Work From Variable Forces
3. Examples

Should you buy a 45 W or a 25 W bulb if they produce the same amount of light?

Meter Number	Service Type	Meter Reading		Read Type		Meter Mult.	Energy Usage
		Previous	Current	Previous	Current		
12192780	Electric	36903.370	37568.030	Actual	Actual	1	664.660

Rate Schedule 001

Basic Charge $6.00			$6.00
First 600 kWh	600.00000 kWh	X $0.08174	49.04
Over 600 kWh	64.66000 kWh	X $0.09237	5.97
Franchise Fee 3%			1.83
		Charges	**$62.84**

Figure: 12.1 Example Power Bill

“I’ve Got The Power!”

Power is the rate at which energy is transferred or transformed.

$$Power = \frac{Change\ in\ Energy}{Time}$$

$$P_{ave} = \frac{\Delta E}{\Delta t}$$

$$1\ watt = 1\ joule/second$$

$$1\ W = 1\ J/s$$

OPSTX Problem 7.33 What is the cost of operating a $3.00\ W$ electric clock for a year if the cost of electricity is $\$0.0900$ per kWh ?

OPSTX Problem 7.34 A large household air conditioner may consume $15.0\ kW$ of power. What is the cost of operating this air conditioner 3.00 h per day for 30.0 d if the cost of electricity is $\$0.110$ per kWh ?

OPSTX Problem 7.33

$$cost = \$0.0900/(kW \cdot h),\ P = 3.00\ W,\ t = 1\ yr = (365.35)(24)\ h$$

$$Energy = Power \times time$$

$$E = (3.00\ W)((365.35 \cdot 24\ h)$$

$$E = 26.3\ kWh$$

$$cost = Rate \times Energy$$

$$cost = (\$0.0900/kWh)(26.3\ kWh)$$

$$cost = \$2.37$$

OPSTX Problem 7.34

$cost = \$0.110/(kW \cdot h)$, $P = 15.00\ kW$, $t = (3.00\ h/day)(30.0\ day) = 90.0\ h$

$$E = P \cdot t$$

$$E = (15.0\ kW)(90\ h)$$
$$E = 135\ kWh$$

$$cost = \frac{\Delta cost}{\Delta E} \cdot E$$

$$cost = (\$0.110/kWh)(135\ kWh)$$
$$cost = \$14.85$$

Variable Forces: How should you approach quantifying total work done by a force that is changing (varying) as a displacement occurs?

Graph it and break the calculation into manageable chunks!

C&J 7.72 Find the work done by the force.

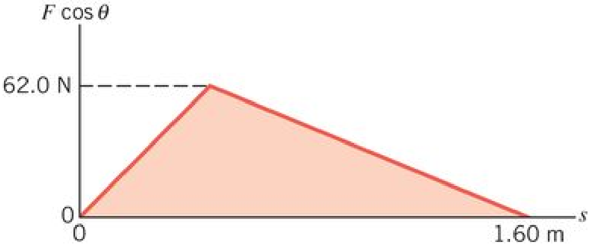

Figure: 12.2 Triangle variable force example; $W = 49.6\ J$

C&J 6.74 The force component along the displacement varies with the magnitude of the displacement, as shown in the graph. Find the work done by the force in the interval from

a. 0 to 1.0 m,

b. 1.0 to 2.0 m, and

c. 2.0 to 4.0 m.

C&J 6.74 Find the work done by the force in the three distinct intervals:

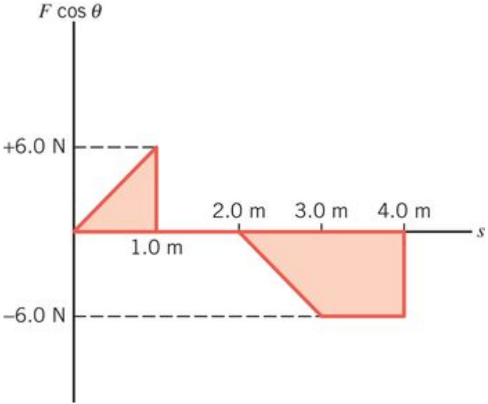

Figure: 12.3 Variable force example

C&J 6.74

a. 0 to 1.0 m:

$$W = \frac{1}{2}(6.0\ N)(1.0\ m)$$

$$W = 3.0\ J$$

b. 1.0 to 2.0 m:

$$W = (0\ N)(1.0\ m)$$

$$W = 0\ J$$

c. 2.0 to 4.0 m:

$$W = \frac{1}{2}(-6.0\ N)(1.0\ m) + (-6.0\ N)(1.0\ m)$$

$$W = -9.0\ J$$

OPSTX Problem 7.36

a. What is the average useful power output of a person who does $6.00 \times 10^6\ J$ of useful work in $8.00\ h$?
b. Working at this rate, how long will it take this person to lift $2000\ kg$ of bricks 1.50 m to a platform? (Work done to lift his body can be omitted because it is not considered useful output here.)

OPSTX Problem 7.36

a. $Work = 6.00 \times 10^6\ J$, $time = 8.00\ h = 28.8 \times 10^3\ s$

$$P_{ave} = \frac{W_{net}}{t}$$

$$P_{ave} = \left(\frac{6.00 \times 10^6\ J}{28.8 \times 10^3\ s}\right)$$

$$P_{ave} = 208\ W$$

b. $F_g = 2000\ N$, $s = 1.50\ m$

$$t = \frac{W_{net}}{P_{ave}}$$

$$t = \left(\frac{3000\ J}{208\ W}\right)$$

$$t = 14.4\ s$$

Problem Solving with Energy

1. Determine the *system of interest* and *identify knowns, unknowns, and goals*. A sketch will help.
2. Examine all the forces involved and determine types of forces and energies are involved.
3. If you know all of the forces are conservative, then you can simplify conservation of energy:

$$KE_o + PE_o = KE_f + PE_f$$

4. If you know some of the forces are nonconservative, then the general conservation of energy law form must be used.

$$KE_o + PE_o + W_{nc} = KE_f + PE_f$$

5. Before solving, eliminate/simplify terms wherever possible.
6. *Check the answer to see if it is reasonable.*

C&J 6.4.33 A bicyclist rides $5.0\ km$ due east, while the resistive force from the air has a magnitude of $3.0\ N$ and points due west. The rider then turns around and rides $5.0\ km$ due west, back to her starting point. The resistive force from the air on the return trip has a magnitude of $3.0\ N$ and points due east.

1. Find the work done by the resistive force during the round trip.
2. Based on your answer to part 33(a), is the resistive force a conservative force? Explain.

C&J 6.4.33 Air resistance force acts during two distinct portions of a bike ride, but has the same effect for both parts of the trip.

$$W \equiv (F cos\theta)s$$

$$W = W_1 + W_2$$

$$W_1 = -(3.0\ N)(5.0\ km)$$

$$W_2 = W_1$$

$$W = -30.0\ kJ$$

Exercise #5

C&J 6.5.39 A slingshot fires a pebble from the top of a building at a speed of 14.0 m/s. The building is 31.0 m tall. Ignoring air resistance, find the speed with which the pebble strikes the ground when the pebble is fired

a. horizontally,

b. vertically straight up, and

c. vertically straight down.

C&J 6.5.39 Let $y_f = 0$. For each case:

$$KE_o + PE_o = KE_f + PE_f$$

$$KE_f = KE_o + PE_o - PE_f$$

$$\frac{1}{2}mv_f^2 = \frac{1}{2}mv_o^2 + mg(y_o - y_f)$$

$$\frac{1}{2}v_f^2 = \frac{1}{2}v_o^2 + g(y_o - y_f)$$

Exercise # 5 Answers

$$\frac{1}{2}v_f^2 = \frac{1}{2}v_o^2 + g(y_o - y_f)$$

$$v_f^2 = v_o^2 + 2gy_o$$

$$v_f = \sqrt{v_o^2 + 2gy_o}$$

$$v_f = \sqrt{(14.0)^2 + 2(10.0)(31.0)}\ m/s$$

$$v_f = \sqrt{816}\ m/s$$

$$v_f = 28.6\ m/s$$

The End

Thanks for your time and attention!
Any questions?

Problem Solving with Energy (Collecting)

1. Determine the *system of interest* and *identify knowns, unknowns, and goals*. A sketch will help.
2. Examine all the forces involved and determine whether you know or are given the potential energy from the work done by the forces.
3. If you know all of the forces are conservative, then you can apply conservation of mechanical energy:

$$KE_o + PE_o = KE_f + PE_f$$

4. If you know some of the forces are nonconservative, then the conservation of energy law in its most general form must be used.

$$KE_o + PE_o + W_{nc} = KE_f + PE_f$$

5. Before solving, eliminate terms wherever possible to simplify the algebra. Ex. Set initial or final height to be zero.
6. *Check the answer to see if it is reasonable.* Check for $\pm$ signs and if speeds or heights are too large or too small.

C&J 6.5.36 A $35.0\ kg$ girl is bouncing on a trampoline. During a certain interval after she leaves the surface of the trampoline, her kinetic energy decreases to 210 J from $440\ J$. How high does she rise during this interval? Neglect air resistance.

C&J 6.5.38 The skateboarder in the drawing starts down the left side of the ramp with an initial speed of $5.4\ m/s$. Neglect nonconservative forces, such as friction and air resistance, and find the height h of the highest point reached by the skateboarder on the right side of the ramp.

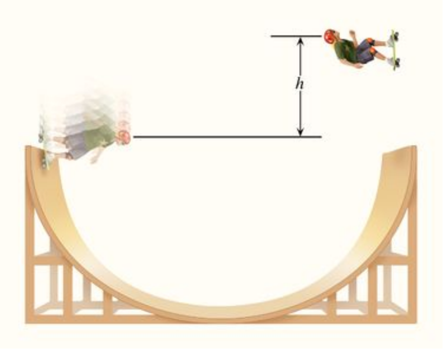

Figure: 12.4 Conservation of Energy Example

C&J 6.7.65 A car accelerates uniformly from rest to $20.0\ m/s$ in $5.6\ s$ along a level stretch of road. Ignoring friction, determine the average power required to accelerate the car if

a. the weight of the car is $9.0 \times 10^3\ N$ and
b. the weight of the car is $1.4 \times 10^4\ N$.

Additional Practice #4

Review Redo kinematics/projectile problem with work/energy methods.