Common Exam 3

April 11th, 2008, Friday

Time: 8:30-9:45 am (Arrive by 8:15 am)
Room: KUPF 205
Bring your scientific calculators
B1. Ch.5 and B2. Ch.7-8

Review session: During class on Thursday before exam
Old exams are posted on course web:

http://web.njit.edu/~kenahn/08spring/phy105.htm

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**Last class we learned about...**

**Spring force**

Hooke’s law:

\[ F_{spring}(x) = -kx \]

- \( x \): displacement from relaxed position
- \( k \): spring constant (N/m)

**Spring Potential Energy**

Spring (elastic) potential energy:

\[ U_{spring}(x) = U_s = \frac{1}{2}kx^2 \]
Mechanical energy:

\[ E_{\text{mech}} \equiv K + U_g + U_s = \frac{1}{2} mv^2 + mgh + \frac{1}{2} kx^2 \]

If \( W_{\text{net}} = W_g + W_s \)

\[ E_{\text{mech}, f} = E_{\text{mech}, i} \]

If \( W_{\text{net}} = W_g + W_s + W_{nc} \)

\[ E_{\text{mech}, f} - E_{\text{mech}, i} = \Delta E_{\text{mech}} = W_{nc} \]

Example: Spring potential (Last class)

A block of mass \( m = 0.40 \text{ kg} \) slides across a horizontal frictionless counter with a speed of \( v = 0.50 \text{ m/s} \). It runs into and compresses a spring of spring constant \( k = 750 \text{ N/m} \). When the block is momentarily stopped by the spring, by what distance \( d \) is the spring compressed?
Example on spring and gravity potential

Power

More examples on “Work and Energy”

Example 1: Spring potential and Gravitational potential

A block of mass $m = 0.40 \, \text{kg}$ drops vertically and encounter the spring with a speed of $v = 0.50 \, \text{m/s}$. It compresses a spring of spring constant $k = 750 \, \text{N/m}$. When the block is momentarily stopped by the spring, by what distance $d$ is the spring compressed?
Power

Work doesn’t depend on the time interval

Work to climb a flight of stairs ~ 3000 J
10 s
1 min
1 hour

Power is work done per unit time

Average Power \[ P_{\text{avg}} = \frac{W}{\Delta t} \]

Instantaneous Power \[ P = \frac{dW}{dt} = F \cdot \frac{dx}{dt} = F v \text{ (in 1D)} \]

Units \[ \frac{\text{Work}}{\text{time}} \] \[ \frac{1 \text{ J}}{1 \text{ s}} = 1 \text{ Watt} \]
1 hp = 746 W

In 2D & 3D, Power: \[ P = \vec{F} \cdot \vec{v} = |\vec{F}| |\vec{v}| \cos \theta_{F,v} \]

Work done by a force
\[ W = |\vec{F}| |\vec{d}| \cos \theta_{F,d} \equiv \vec{F} \cdot \vec{d} \]

Power done by a force
\[ P = |\vec{F}| |\vec{v}| \cos \theta_{F,v} \equiv \vec{F} \cdot \vec{v} \]
Two constant forces $\mathbf{F}_1$ and $\mathbf{F}_2$ acting on a box as the box slides rightward across a frictionless floor. Force $\mathbf{F}_1$ is horizontal, with magnitude 2.0 N, force $\mathbf{F}_2$ is angled upward by 60° to the floor and has a magnitude of 4.0 N. The speed $v$ of the box at a certain instant is 3.0 m/s.

a) What is the power due to each force acting on the box?
b) What are the powers by the normal force and by the gravity?
c) What is the net power?

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Example 3

Killer whales are known to accelerate very fast. Calculate the average power a killer whale with mass 8000 kg would need to generate to reach a speed of 12.0 m/s from rest in 6.0 s. Assume water resistance is negligible.
Example 4

What average power would a 1000 kg speedboat need to go from rest to 20 m/s in 5.0 s, assuming the water exerts a constant drag force of magnitude $f_d = 500$ N and the acceleration is constant?