PHY 113 A General Physics I
9-9:50 AM MWF Olin 101

Plan for Lecture 36:

Review – Part I

1. General advice about how to study
2. Some comments on sound and waves
3. Review of past exam questions

Review – Part II (Friday)

1. Systematic review of PHY 113 topics

23	11/05/2012	Fluid mechanics	14.1-14.4	14.8, 14.24	11/07/2012
24	11/07/2012	Fluid mechanics	14.5-14.7	14.39, 14.51	11/09/2012
25	11/09/2012	Temperature	19.1-19.5	19.1, 19.20	11/12/2012
26	11/12/2012	Heat	20.1-20.4	20.3, 20.14, 20.24	11/14/2012
27	11/14/2012	First law of thermodynamics	20.5-20.7	20.26, 20.35	11/16/2012
28	11/16/2012	Ideal gases	21.1-21.5	21.10, 21.19	11/19/2012
29	11/19/2012	Engines	22.1-22.8	22.3, 22.62	11/26/2012
	11/21/2012	*Thanksgiving Holiday*			
	11/23/2012	*Thanksgiving Holiday*			
	11/26/2012	Review	14,19-22		
	11/28/2012	Exam	14,19-22		
30	11/30/2012	Wave motion	16.1-16.6	16.5, 16.22	12/03/2012
31	12/03/2012	Sound & standing waves	17.1-18.8	17.35, 18.35	12/05/2012
	12/05/2012	Review	1-22		
	12/07/2012	Review	1-22		
	12/13/2012	Final Exam -- 9 AM			

Comments on final exam for PHY 113

Date: Thursday, Dec. 13, 2012 at 9 AM
Place: Olin 101
Format: Similar to previous exams; covering material in Lectures 1-37, Chapters 1-22 (no time pressure)
Focus: Basic physics concepts; problem-solving techniques
Bring:

1. Clear head
2. Calculator
3. Pencils, pens
4. Up to 4 equation sheets

iclicker question:

What is the purpose of the final exam in PHY 113

A. No purpose – just pain and suffering
B. To improve my grade in the course
C. It is a college tradition that must be maintained
D. To check that I have actually learned the material
E. To encourage students to review the course material and solidify my learning

Comments on waves and sound

1. **Standing wave resonances for strings or pipes**
2. **Relationship between wave speed, frequency, and wavelength**
3. **Doppler effect**

Formation of standing waves; beautiful trigonometric identity: $\sin A \pm \sin B = 2\sin\left[\tfrac{1}{2}\left(A \pm B\right)\right]\cos\left[\tfrac{1}{2}\left(A \mp B\right)\right]$

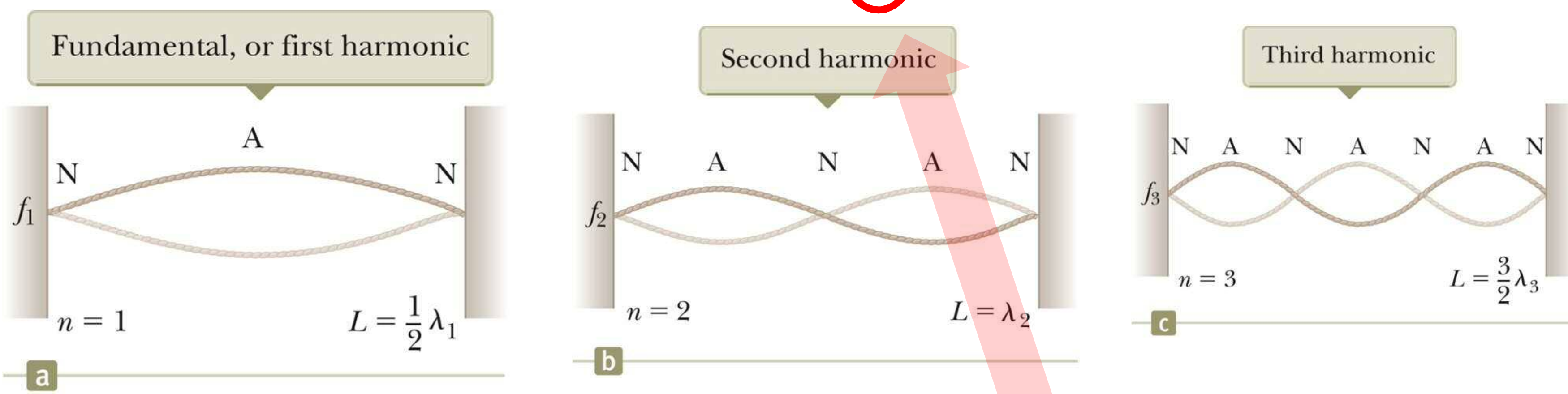
$$y_{right}(x,t) = y_0 \sin\left(\frac{2\pi}{\lambda}\left(x - ct\right)\right) \qquad y_{left}(x,t) = y_0 \sin\left(\frac{2\pi}{\lambda}\left(x + ct\right)\right)$$

"Standing" wave***:*** ***($\lambda f=c$)***

$$y_{right}(x,t) + \mathrm{y}_{left}(x,t) = 2y_0 \sin\left(\frac{2\pi x}{\lambda}\right)\cos\left(2\pi f t\right)$$

Possible spatial shapes for transverse string wave:

$$y(x,0) = A\sin\left(\left(\frac{n}{2L}\right)2\pi x\right) \qquad n = 1,2,3,4.....$$



Standing wave form: $y(x,t) = A\sin\left(\frac{2\pi x}{\lambda}\right)\cos(2\pi f t)$

$$\Rightarrow \lambda_n = \frac{2L}{n} \qquad f_n = \frac{nc}{2L} \qquad n = 1,2,3,4..........$$

Musical scale (chromatic)

Chromatic Scale	
A	440.00 Hz
A#/Bb	466.16 Hz
B	493.88 Hz
C	523.25 Hz
C#/Db	554.37 Hz
D	587.33 Hz
D#/Eb	622.25 Hz
E	659.25 Hz
F	698.46 Hz
F#/Gb	739.99 Hz
G	783.99 Hz
G#/Ab	830.61 Hz
A	880.00 Hz

For standing waves on a string:

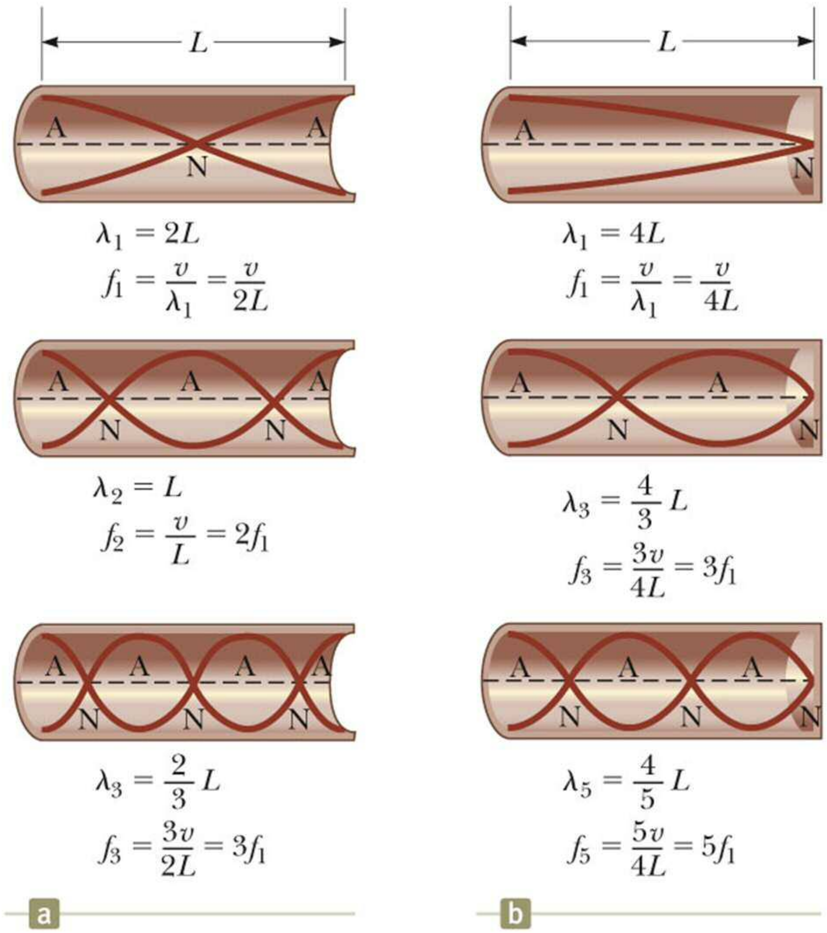
$$f_n = \frac{nc}{2L} \qquad n = 1,2,3,4..........$$

Example: for A: $f_1 = 440$ Hz on a 0.5 m string,

must set $c = 440$ m/s (by adjusting tension)

$f_2 = 880$ Hz ($n = 2$ harmonic)

Standing waves in air c=343 m/s:



For open - open standing waves:

$$f_n = \frac{nc}{2L} \qquad n = 1,2,3,4..........$$

For $L = 0.39$ m

A: $f_1 = 440$ Hz

$f_2 = 880$ Hz

For open - closed standing waves:

$$f_n = \frac{nc}{4L} \qquad n = 1,3,5..........$$

For $L = 0.39$ m

A: $f_1 = 220$ Hz

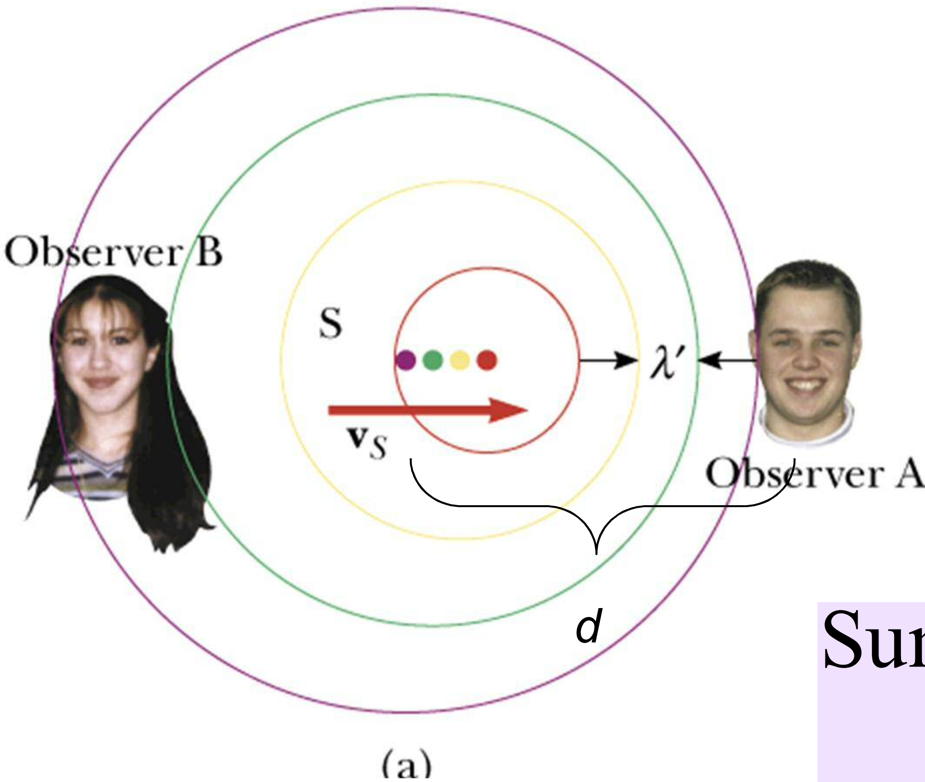
$f_3 = 660$ Hz

The "Doppler" effect

v=sound velocity

observer stationary, source moving

Serway, Physics for Scientists and Engineers, 5/e
Figure 17.11a



$$vt_1 = d$$

$$v(t_2 - T) + v_S T = d$$

$$t_2 - t_1 = \frac{1}{f_O} = T\frac{v - v_S}{v}$$

$$f_O = f_S \frac{v}{v - v_S}$$

$$\text{Summary}: \quad f_O = f_S \frac{v \pm v_O}{v \mp v_S}$$

toward

away

Summary of sound Doppler effect:

$$f_O = f_S \frac{v \pm v_O}{v \mp v_S}$$

toward

away

Doppler effect for electromagnetic waves:

$$f_O = f_S \sqrt{\frac{v + v_R}{v - v_R}}$$

Relative velocity of source toward observer

Example: $f_S = 440$ Hz and suppose $v_S = 0$ and $v_O = v_R = 30$m/s

For sound $v = 343$m/s $\quad f_O = 440/(1 - 30/343)$ Hz $= 482$ Hz

For radar $v = 3\times10^8$ m/s $\quad f_O - f_S = 440\sqrt{\frac{1 + 30/3\times10^8}{1 - 30/3\times10^8}}$ Hz $= 4.4\times10^{-5}$ Hz

iclicker question:

The previous calculation for "radar" Doppler was:

A. Encouraging me to speed because it is impossible to detect such a small frequency difference
B. Full of admiration that Doppler radar equipment can detect such a small frequency difference
C. Not relevant to actual "radar" Doppler -- still need to be careful not to speed

iclicker question:

The fallacy in the previous analysis was

A. Incorrect value of f_s
B. Incorrect value of v (speed of light)
C. Calculator error

Doppler effect for electromagnetic waves :

$$f_O = f_S \sqrt{\frac{v + v_R}{v - v_R}}$$

Relative velocity of source toward observer

Typical radar frequencies : $f_S = 20\times10^9$ Hz; suppose $v_R = 30$m/s

For radar $v = 3\times10^8$ m/s $\quad f_O - f_S = 20\times10^9 \sqrt{\frac{1+30/3\times10^8}{1-30/3\times10^8}}\text{Hz} = 2\times10^3$ Hz

2. –/0.5 points My Notes | SerPSE8 17.P.035.

A driver travels northbound on a highway at a speed of 28.0 m/s. A police car, traveling southbound at a speed of 34.0 m/s, approaches with its siren producing sound at a frequency of 2550 Hz.

(a) What frequency does the driver observe as the police car approaches?

_____ Hz

(b) What frequency does the driver detect after the police car passes him?

_____ Hz

(c) Repeat parts (a) and (b) for the case when the police car is traveling northbound.

while police car overtakes _____ Hz

after police car passes _____ Hz

6. ⊕ –/0.5 points

My Notes | SerPSE8 18.P.035

The fundamental frequency of an open organ pipe corresponds to the E above middle C (329.6 Hz on the chromatic musical scale). The third resonance of a closed organ pipe has the same frequency. (Assume that the speed of sound in air is 343 m/s.)

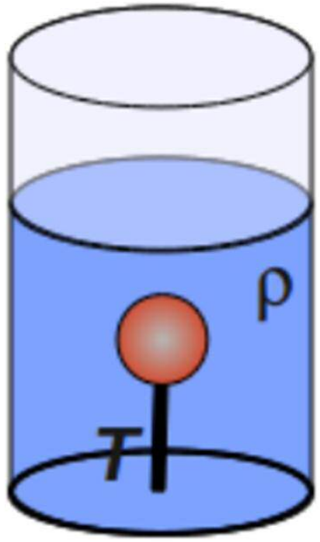
(a) What is the length of the open pipe?

____ m

(b) What is the length of the closed pipe?

____ m

Review questions from Exam 4:



1.

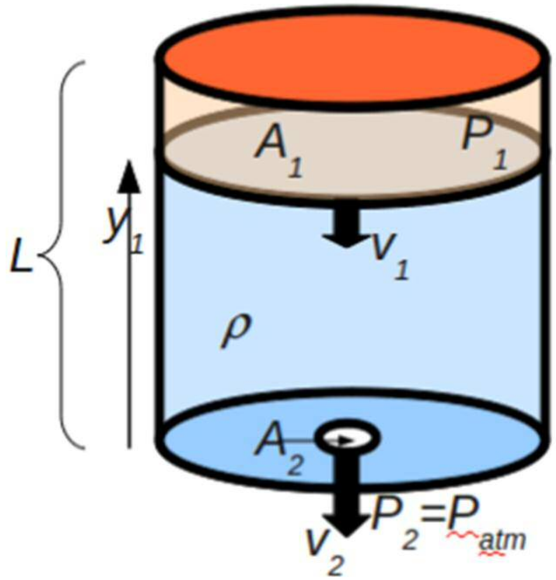
The drawing above shows a spherical ball, having a volume of $V = 2 \times 10^{-4}$ m^3, completely submerged in a fluid of density $\rho = 2000$ kg/m^3. The ball is attached to bottom of the container with a massless rope which has a tension of $T = 2$ N. Above the fluid, is air at atmospheric pressure. For the purpose of solving this problem, the density of air is negligible.

(a) Calculate the buoyant force acting on the ball.

(b) Calculate the mass of the ball.

(c) If the rope were released from the bottom of the container, what would be the new equilibrium position of the ball?

Review questions from Exam 4:



2.

The drawing above shows an enclosed cylindrical container of height $L = 0.4$ m with a cross sectional area $A_1 = 0.2\ \text{m}^2$. An incompressible liquid of density $\rho = 2000\ \text{kg/m}^3$ is filled within the container to a height of $y_1 = 0.3$ m. In the space between the closed top of the container and the liquid at height y_1, is a gas (assumed to obey the ideal gas law) composed of vapor and air at a pressure $P_1 = P_{atm}$. At the bottom of the container (height $y_2 = 0$) is a small plug with a cross sectional area $A_2 = 0.04\ \text{m}^2$.

(a) When the plug at the bottom of the container is removed, the liquid flows out at a velocity v_2 while the liquid level at y_1 moves at a velocity v_1. Assuming that Bernoulli's equation is appropriate for this system, find the values of the velocities v_1 and v_2.

(b) After some time, the liquid height in the container is reduced to $y_1' = 0.2$ m. Assuming that this occurs at constant temperature T, determine the new value of the pressure P_1' due to the air-vapor mixture above the liquid.

(c) Explain in words what you expect to happen with the liquid velocity v_2' compared to its value v_2 when the plug was just removed.

Review questions from Exam 4:

3. In this problem, we will assume that we have $n = 2$ moles of an ideal gas confined within a thermally insulated container having a volume of 0.1 m^3. The gas has an initial temperature of T_i=600° K. We will also assume that the internal energy of the gas is well modeled by the equation

$$E_{int}(T) = \frac{1}{\gamma - 1} nRT,$$

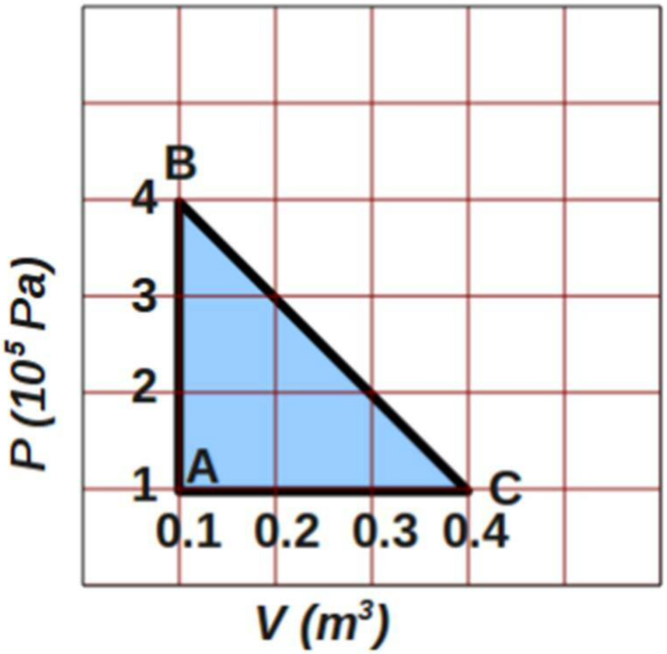
where in this case, the constant is given by $\gamma = 1.5$.

(a) What is the initial $E_{int}(T_i)$ of the gas?

(b) What is the change in the internal energy (ΔE_{int}) after heat in the amount of $Q = 6000$ J is added to the system in the constant volume and insulated container?

(c) What is the subsequent temperature of the gas within the container?

Review questions from Exam 4:



4.

The graph above shows a $P-V$ diagram of a thermodynamic cycle on an ideal gas for $A \rightarrow B \rightarrow C \rightarrow A$. We will again assume that the internal energy of the ideal gas is well modeled by the equation

$$E_{int}(T) = \frac{1}{\gamma - 1} nRT,$$

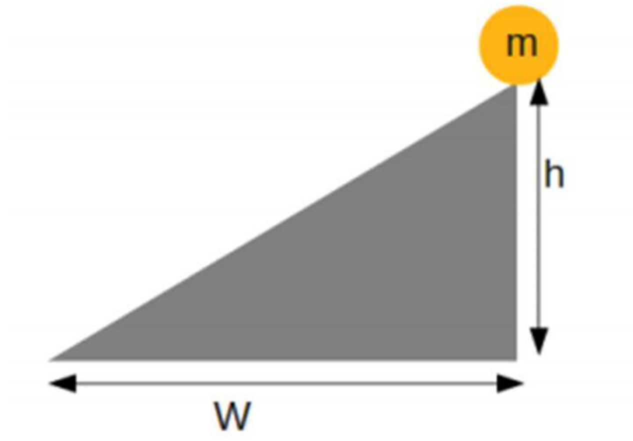
where in this case, the constant is given by $\gamma = 1.5$.

(a) What is the net work done on the system each cycle?

(b) What is the net heat added to the system each cycle?

(c) What is the change in the internal energy of the system each cycle?

Review questions from Exam 3:



1.

This problem concerns notions of energy conservation as well as rotational motion. The figure shows an object with mass $m = 5kg$, radius $R = 0.04m$, and moment of inertia $I = 0.006$ kg·m^2, initially at rest on the top of an incline of height $h = 0.6$ m and width $W = 1.2$ m. The 2 questions involve 2 different conditions for the interaction of the object with respect to the surface of the incline. You can assume that the mass in the object is distributed so that the center of mass of the object coincides with center of the object.

(a) In the first case, consider what happens when the object slides down the incline without friction and without rotating.

  i. What is the initial energy (kinetic, potential, and total) of the system?

  ii. What is the final energy (kinetic, potential, and total) of the system when the object reaches in the end of the incline?

  iii. What is the final speed of the center of mass of the object?

(b) In the second case, consider what happens when the object rolls without slipping down the incline.

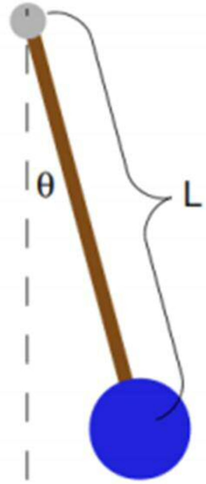
  i. What is the initial energy (kinetic, potential, and total) of the system?

  ii. What is the final energy (kinetic, potential, and total) of the system when the object reaches in the end of the incline?

  iii. What is the final speed of the center of mass of the object?

  iv. What is the final angular velocity of the object?

Review questions from Exam 3:



3.

The figure above shows a thin rod of length $L = 3$ m and of negligible mass. A mass m=5 kg is attached to the end of the rod. For the purpose of analyzing this problem, it is a good approximation to assume that the angular displacement θ measured in radians is small enough so that

$$\sin\theta \approx \theta.$$

(a) Initially, the rod-mass system is displaced from equilibrium by an angle $\theta(t = 0) = 0.26$ radians.

i. At $t = 0$, the rod-mass system is released from rest. Find the angular displacement $\theta(t)$ for $t > 0$. In expressing your answer, evaluate all of the parameters except for the variable time t.

ii. Find the maximum angular speed $\omega(t)$ of the rod-mass system.

iii. Find the maximum angular acceleration $\alpha(t)$ of the rod-mass system.

(b) Now the rod-mass system is connected to a motor which applies a harmonic driving torque of the form

$$\tau_{driving} = \tau_0 \sin(\Omega t),$$

where $\tau_0 = 1.5$ Nm and $\Omega = 2$ rad/s.

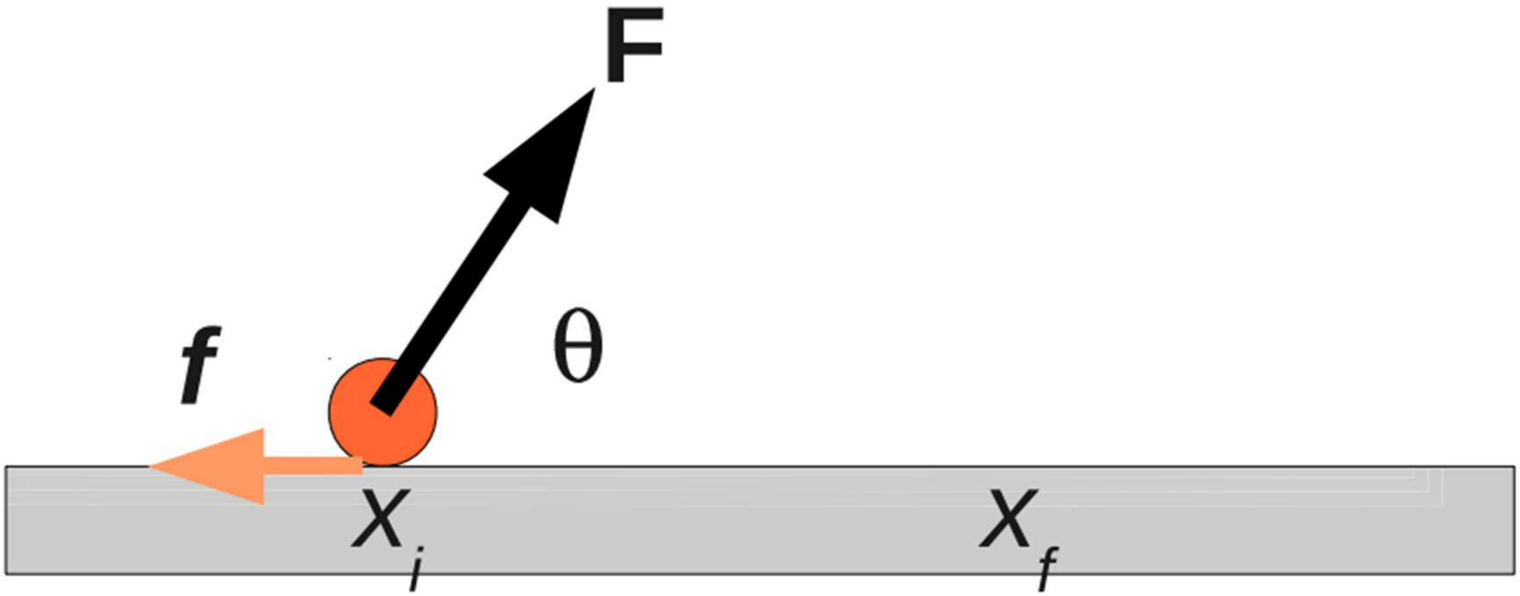
i. Show that a solution to the driving rod-mass system can be written in the form

$$\theta(t) = \Theta_0 \sin(\Omega t),$$

where Θ_0 is a constant (independent of time).

ii. Evaluate the magnitude of Θ_0 from the given information.

Review questions from Exam 2:



1.

The figure above shows an object of mass $m = 30kg$ which is being pulled along a horizontal surface by a pull force of $\mathbf{F} = 50N$ at an angle of $\theta = 70^o$ measured with respect to the horizontal, while a constant opposing friction force of $f = 3N$ is also acting on the object. Assume that that the object starts at position x_i at rest and the final position is given by $x_f = x_i + 4m$.

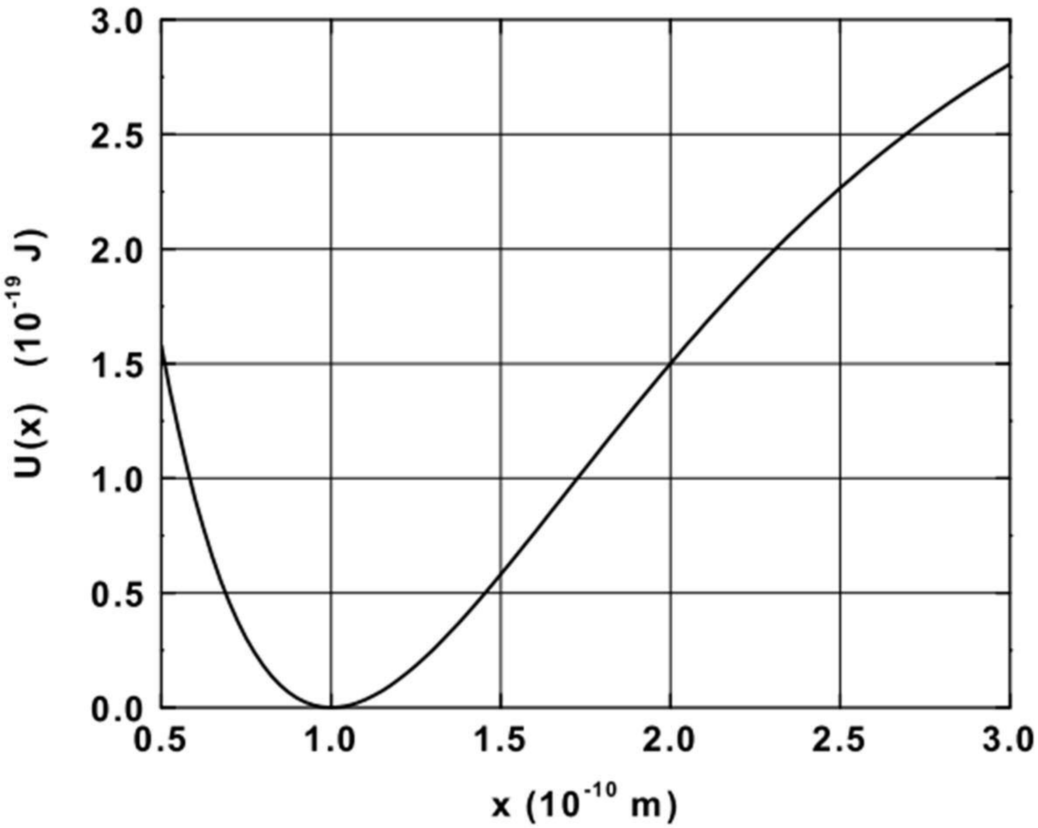
(a) What is the work done by the pull force $\mathbf{F}$ in moving the object from x_i to x_f?

(b) What is the total work done by the combination of the pull force $\mathbf{F}$ and the friction force f in moving the object from x_i to x_f?

(c) What is the final kinetic energy of the object when it reaches the position x_f?

(d) What is the final velocity of the object when it reaches the position x_f?

Review questions from Exam 2:



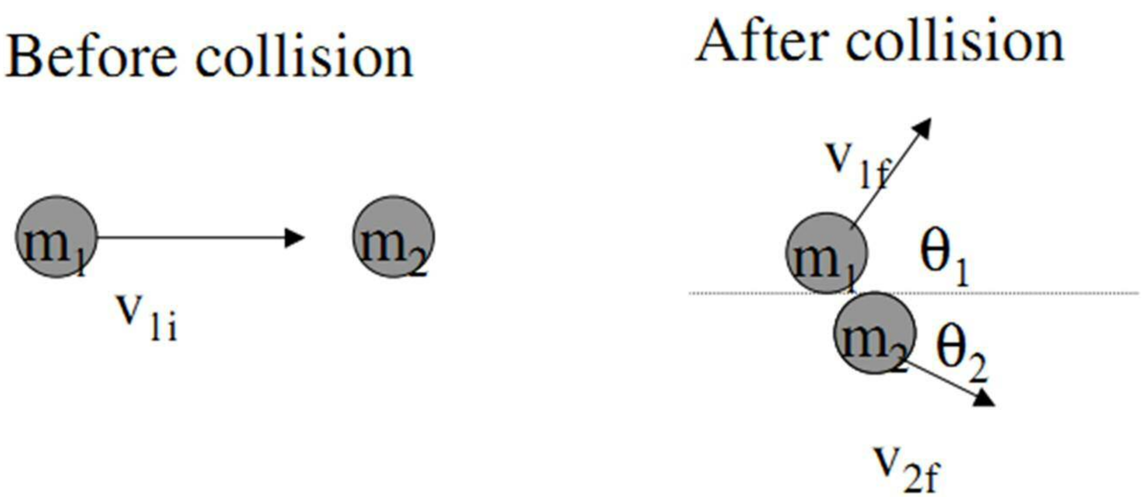
2.

The figure above shows a plot of potential energy U (in units of 10^{-19} Joules), associated with the conservative forces between two atoms in a molecule, as a function of their separation x in units of 10^{-10}m. For the purposes of this problem, we will focus on the motion and energy associated with the separation of the atoms, assumed to be confined to the x direction.

(a) What is the work by the interaction forces in the molecule as its separation changes from $x_i = 1 \times 10^{-10}$m to $x_f = 2 \times 10^{-10}$m?

(b) What is the kinetic energy of the molecule when its separation is $x_f = 2 \times 10^{-10}$m, if $K_i = 2 \times 10^{-19}$J at a separation of $x_i = 1 \times 10^{-10}$m?

Review questions from Exam 2:



3.

The figure above shows a collision process which takes place in the absence of any external forces. Initially mass m_1 has a velocity of $v_{1i} = 8\text{m/s}$ and mass m_2 is at rest. After the collision, mass m_1 has a final velocity of $v_{1f} = 4\text{m/s}$, moving at an angle $\theta_1 = 60^o$ with respect to its initial position and mass m_2 has a final velocity of $v_{2f} = 3\text{m/s}$, moving at an angle $\theta_2 = 30^o$. It is known that mass $m_1 = 4\text{u}$ ($1\ \text{u} = 1.66 \times 10^{-27}\text{kg}$).

(a) Write down the equations that represent conservation of the two components of momentum in the plane of the collision.

(b) Solve one of the equations to find the mass m_2.

(c) Check whether the second equation is consistent with the same value of mass m_2.

(d) Is energy conserved in this collision?