Announcements 11 May 09

- Homework #13
  - Online homework #13 due tomorrow by 8 am
    - Problem 15.35: use v_{sound} = 343 m/s
- Final exam
  - Thu May 14 from 1:30 to 3:30 pm
  - See info on blog
- Grades
  - Update later today with exam 3 + adjusted PRS/WH

38

Course Grade

- Do you need to take the final exam?
  - No, the final exam is optional
  - Not taking the final exam would mean getting a score of 0 and having it taken as the lowest of your 4 exam scores that is dropped
  - But remember that the final exam cannot hurt you, it can only improve your grade
- Homework grade
  - You can still work on problems you did not yet submit but no more work allowed after Wed May 20 at 4 pm
  - A 50% late penalty will be applied to those late submissions (assessed on a per-problem basis)

39

Final Exam Information (I)

- What will be covered?
  - Motion and kinematics
    - Projectile motion (Chapter 3)
  - Motion and forces
    - Newton's laws (Chapter 4)
    - Friction, tension, weight, normal force and inclined planes (Chapter 5)
  - Momentum and energy conservation
    - Collisions and explosions (Chapter 9)
    - Work, kinetic energy, potential energy, thermal energy (Chapter 10)
  - Waves
    - Mechanical waves (Chapter 15)
    - Standing waves on a string and in a tube (Chapter 16)

40

Final Exam Information (II)

- What is not covered?
  - Apparent weight
  - Gravitational force
  - Center of gravity and Torque
  - Temperature and Heat
  - Oscillations

41

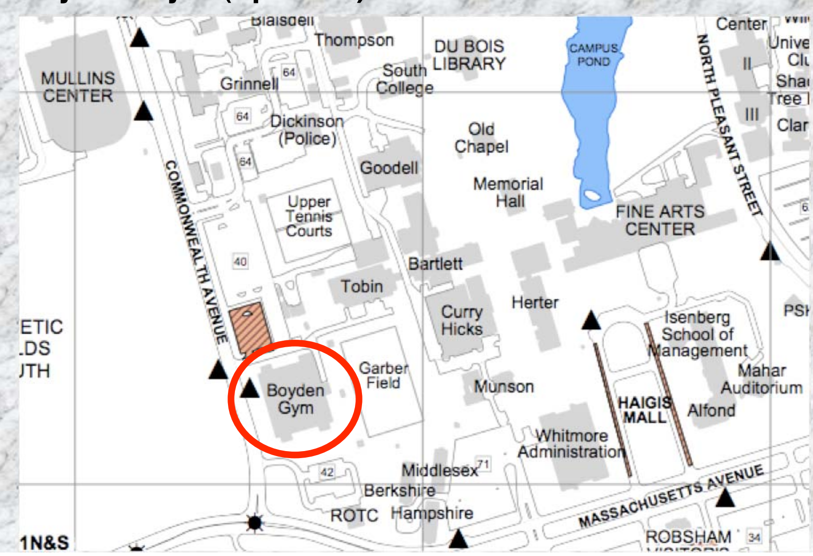
Final Exam Information (III)

- **Exam format**
  - Multiple choice (no written problem)
  - Mixture of conceptual questions (PRS like) and numerical problems (homework like)
  - Sample exam provided for practice (sample exam will be discussed during the special help session)
- **Grade**
  - Lowest score on the 4 exams will be dropped
    ➔ your grade can only improve with the final exam!

42

Final Exam Information (IV)

- **Exam on Thursday May 14 from 1:30 to 3:30 pm**
  - Boyden Gym (upstairs)



Final Exam Information (V)

- What to take to the exam?
  - Bring calculator, #2 pencil, student ID + a single *hand-written* formula sheet (filled on both sides)
  - No scratch paper (should not be needed)
  - No book
- Resources
  - Help session on Wednesday May 13 from 2:00 to 4:00 pm in HAS 20
  - Sample exam + previous exams + homework + lecture notes + textbook problems (answers to odd-numbered problems are in the back of the book)

44

Final Exam: units

Use SI units

Generally need to convert all quantities to SI units

distance unit:	m
mass unit:	kg
time unit:	s
force unit:	N (or kg m/s^2)
momentum unit:	kg m/s
energy unit:	J (or kg m^2/s^2)

Conversions

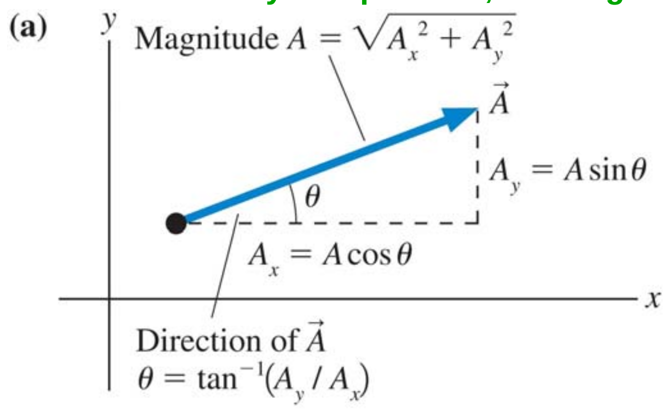
1 km = 10^3 m
1 cm = 10^{-2} m
1 mi = 1600 m
1 gram= 10^{-3} kg
1 h = 3600 s
1 min = 60 s
1 lb = 4.45 N

360^o = 2π radians

45

Final Exam: vectors & concepts

Work with x- and y-components, and angle θ



Know and understand main concepts in the lecture notes

Newton's laws, momentum, energy, work, collisions, waves

46

Final Exam: Equation toolkit

Motion kinematics

valid only if constant acceleration
btw initial time t_i and final time t_f

$$(v_x)_f = (v_x)_i + a_x \Delta t$$
$$(v_x)_f^2 = (v_x)_i^2 + 2a_x \Delta x$$
$$x_f = x_i + (v_x)_i \Delta t + \tfrac{1}{2} a_x (\Delta t)^2$$

Projectile 2D motion $a_x = 0$ and $a_y = -g$

$$(v_x)_f = (v_x)_i$$
$$x_f = x_i + (v_x)_i \Delta t$$

$$(v_y)_f = (v_y)_i - g\Delta t$$
$$(v_y)_f^2 = (v_y)_i^2 - 2g\Delta y$$
$$y_f = y_i + (v_y)_i \Delta t - \tfrac{1}{2} g (\Delta t)^2$$

Compute Δt to relate motion along x-axis to motion along y-axis

If Δy is given, generally compute Δt from y-motion

If Δx is given, generally compute Δt from x-motion

47

Final Exam: Equation toolkit

Newton's 2nd law

$$\sum F_x = ma_x$$
$$\sum F_y = ma_y$$

Forces and motion

acceleration is the link between forces and motion

If given forces acting on an object:

1. Identify forces & draw free-body diagram
2. Compute net force along x and y axes (or just 1 axis as required)
3. Compute corresponding acceleration using Newton's 2nd law
4. Use kinematics equations (previous slide) to determine the change in motion (e.g. find final position, velocity, etc.)

If given information about motion (e.g. displacement Δx, time interval Δt, initial and/or final velocities):

1. Use kinematics equations and motion information to compute the acceleration
2. Compute magnitude and direction of net force using Newton's 2nd law

48

Final Exam: Equation toolkit

Different forces

1. Tension — T directed along a string or rope
2. Weight — $w = m g$
3. Normal force — n perpendicular to surface of two objects in contact
   ($n = m g$ not true in general, true only in special cases)
4. Friction — static: $f_s\ max = \mu_s n$; kinetic: $f_k = \mu_k n$

49

Final Exam: Equation toolkit

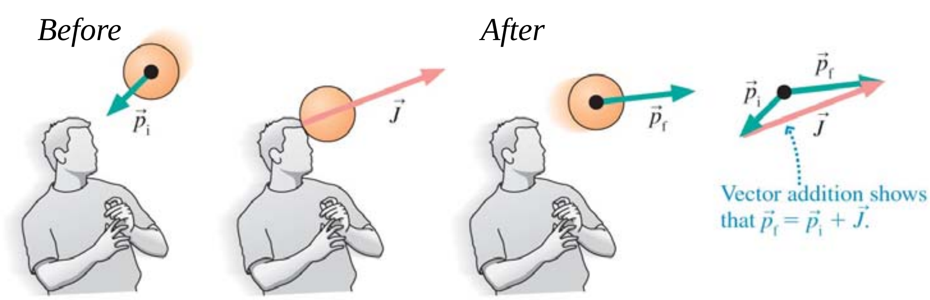
Impulse (J) and Momentum (p)

remember these are vector quantities
important to keep track of direction
(negative for motion to the left)

$$\vec{J} = \vec{p}_f - \vec{p}_i = \Delta\vec{p}$$

$$\vec{p} = m\vec{v}$$

m: mass of object
v: velocity of object



50

Final Exam: Equation toolkit

Collisions and Explosions

analyze with *momentum conservation* (p is vector quantity!)
can apply momentum conservation if system is isolated or if external forces can be neglected during brief moment of collision

SOLVE The mathematical representation is based on the law of conservation of momentum: $\vec{P}_f = \vec{P}_i$. In component form, this is

$$(p_{1x})_f + (p_{2x})_f + (p_{3x})_f + \cdots = (p_{1x})_i + (p_{2x})_i + (p_{3x})_i + \cdots$$
$$(p_{1y})_f + (p_{2y})_f + (p_{3y})_f + \cdots = (p_{1y})_i + (p_{2y})_i + (p_{3y})_i + \cdots$$

typical cases: 1. collision between two objects
2. explosion into two parts
(P_i = 0 if "exploding" object is at rest)

51

Final Exam: Equation toolkit

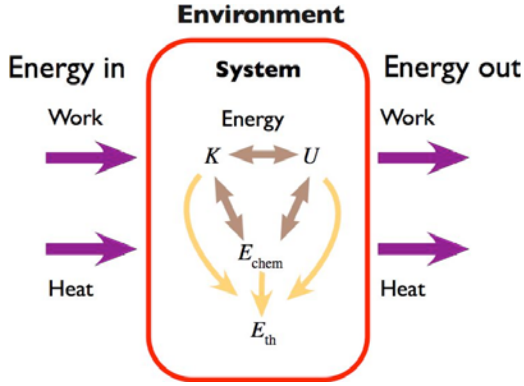
Energy

- A system is characterized by a total energy *E*

  $E = K + U_g + U_s + E_{th} + E_{chem} + \ldots$

- Energy is conserved if system is isolated, or $\Delta E = W+Q$

  $\Delta K + \Delta U_g + \Delta U_s + \Delta E_{th} + \ldots = W + Q$



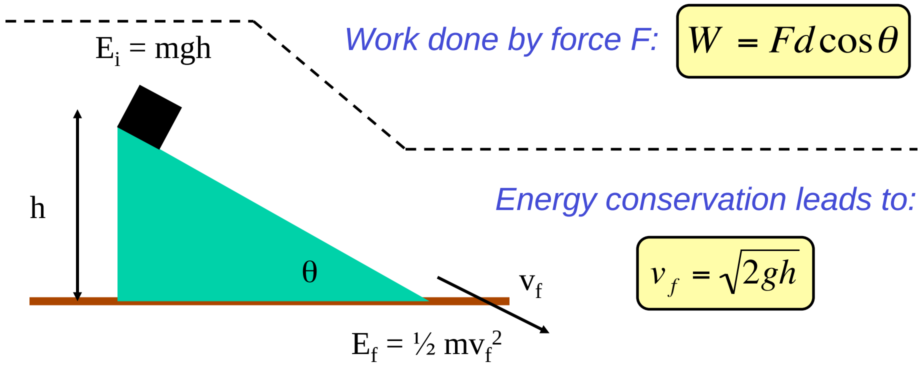
52

Final Exam: Equation toolkit

Energy

- Kinetic energy $K = \frac{1}{2}mv^2$
- Gravitational potential energy $U_g = mgy$
- Spring potential energy $U_s = \frac{1}{2}kx^2$

Work done by force F: $W = Fd\cos\theta$



Energy conservation leads to:

$$v_f = \sqrt{2gh}$$

53

Exam 3: Equation toolkit

Collisions

- Perfectly elastic:

momentum and mechanical energy is conserved $\vec{P}_i = \vec{P}_f$ $K_i + U_i = K_f + U_f$

- Perfectly inelastic:

(objects "stick" together after the collision) $\vec{P}_i = \vec{P}_f$

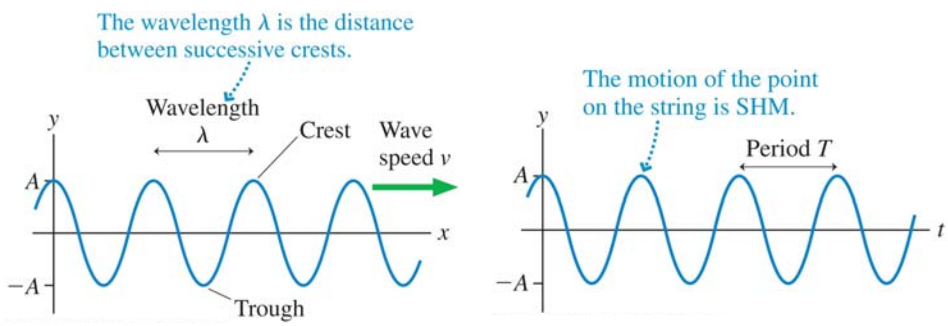
only momentum is conserved

54

Final Exam: Equation toolkit

Waves

Periodic disturbances propagating through medium
transfer energy but not matter
(electromagnetic waves like light do not need medium)



1. Wave source determines amplitude A, frequency $f \Rightarrow$ period T
2. Medium determines speed $v = \lambda f = \lambda / T \Rightarrow$ wavelength λ

55

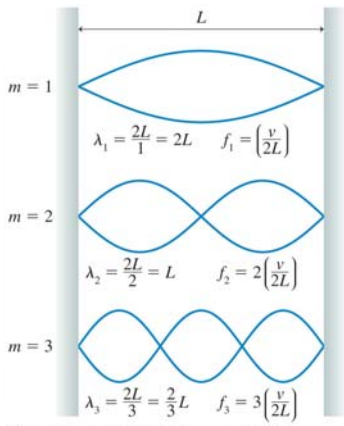
Final Exam: Equation toolkit

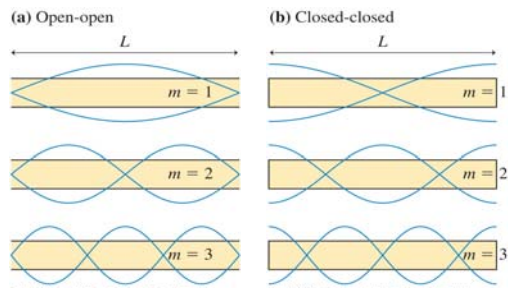
Standing Waves

String with fixed ends, and open-open or closed-closed tube oscillate at fixed resonant frequencies that depend on the string or tube length L

$$\lambda_m = \frac{2L}{m} \qquad m = 1,2,3,4,\ldots$$

$$f_m = m\left(\frac{v}{2L}\right)$$



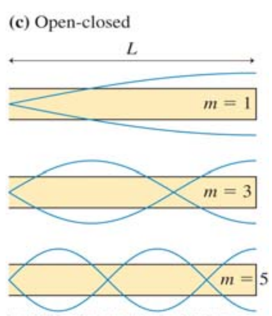


56

Final Exam: Equation toolkit

Standing Waves

Open-closed tube oscillates at fixed resonant frequencies that depend on the tube length L



$$\lambda_m = \frac{4L}{m} \qquad m = 1,3,5,7,\ldots$$

$$f_m = m\left(\frac{v}{4L}\right)$$

Useful to know: wave speed on string with tension T_s and mass per unit length μ

$$v = \sqrt{\frac{T_s}{\mu}}$$

57

Standing Wave Modes

Standing wave on a string of length L needs to satisfy the following criteria:

- Displacements at x = 0 and x = L must be zero at all times (since string is attached at both ends)
- Nodes are equi-distant with a separation of $\lambda/2$

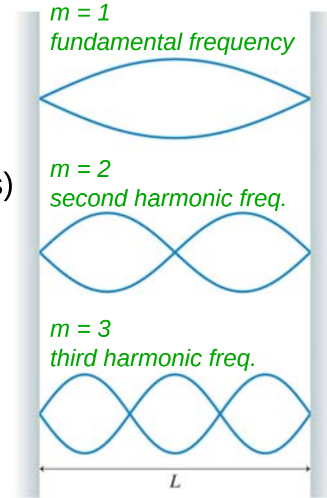
Standing wave has different modes of oscillation with specific wavelengths and frequencies:

$$\lambda_m = \frac{2L}{m} \qquad m = 1, 2, 3, 4, \ldots \qquad (16.1)$$

Wavelengths of standing wave modes of a string of length L

$$f_m = \frac{v}{\lambda_m} = \frac{v}{2L/m} = m\left(\frac{v}{2L}\right) \qquad m = 1, 2, 3, 4, \ldots \qquad (16.2)$$

Frequencies of standing wave modes of a string of length L



DEMOS: Standing wave on a string + Tacoma Narrows bridge (1940)

58

Standing Sound Waves in Tubes

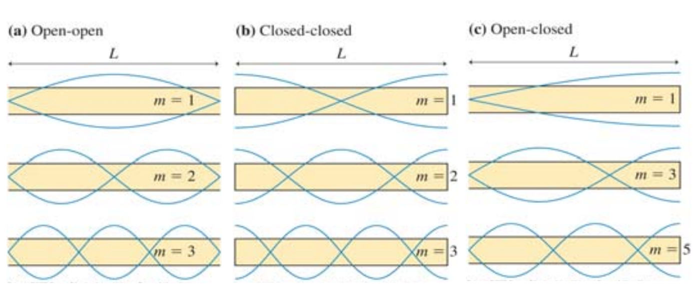
DEMOS:
Slide whistle
Resonance cavities
Hollow tubes
Dancing flames

$$\begin{cases} \lambda_m = \dfrac{2L}{m} \\ f_m = m\left(\dfrac{v}{2L}\right) = mf_1 \end{cases} \qquad m = 1, 2, 3, 4, \ldots$$

Wavelengths and frequencies of standing sound wave modes in an open-open or closed-closed tube

$$\begin{cases} \lambda_m = \dfrac{4L}{m} \\ f_m = m\dfrac{v}{4L} = mf_1 \end{cases} \qquad m = 1, 3, 5, 7, \ldots$$

Wavelengths and frequencies of standing sound wave modes in an open-closed tube



59

Fundamental frequency question 2

A tube that is open at both ends supports a standing wave with harmonics at 300 Hz and 400 Hz, with no harmonics in between. What is the fundamental frequency of this tube?

A. 50 Hz
B. 100 Hz
C. 150 Hz
D. 200 Hz
E. 300 Hz

60

Announcements 11 May 09

GOOD LUCK WITH FINAL EXAMS

HAVE A GREAT SUMMER!!!!

61