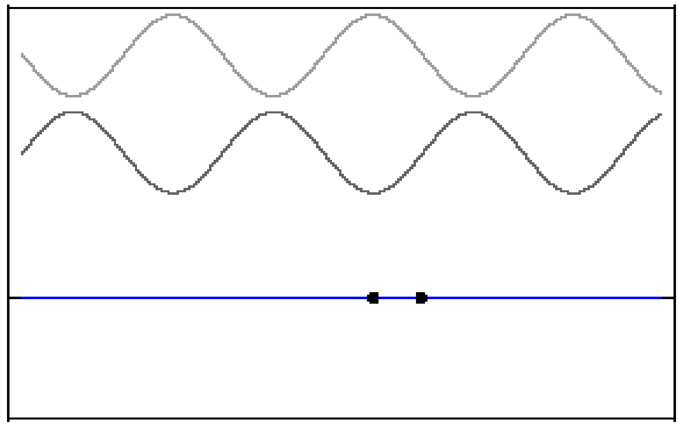
PHY131H1F - Class 35



Today:

11.9 Standing Waves in Air Columns

11.10 The Doppler Effect

Course Review

Final Assessment Details

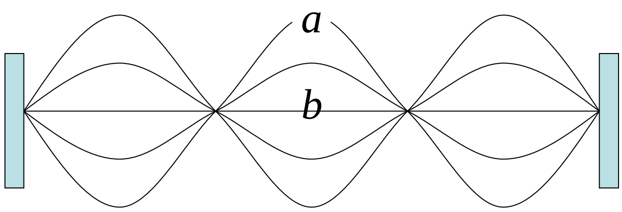
1

Standing Waves

- Are a form of “resonance”
- There are multiple resonant frequencies called harmonics
- The boundary conditions and speed of waves determine which frequencies are allowed.
- The ends of the resonant cavity have forced nodes or antinodes

2

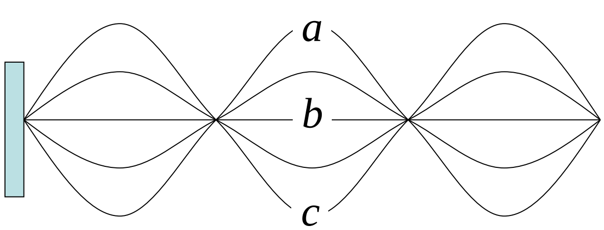
Poll



- A string is clamped at both ends and plucked so creates a standing wave. Define upward motion to be positive velocities. When the string is in position a, the instantaneous velocity of points along the string
- A. is zero everywhere
- B. is positive everywhere
- C. is negative everywhere
- D. depends on location

3

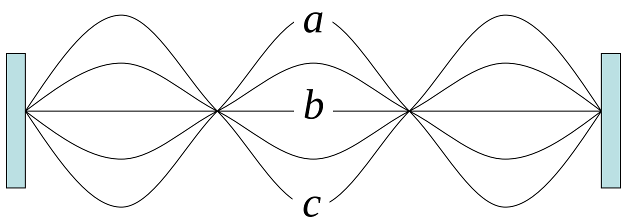
Poll



- A string is clamped at both ends and plucked so creates a standing wave. Define upward motion to be positive velocities. When the string is in position b, the instantaneous velocity of points along the string
- A. is zero everywhere
- B. is positive everywhere
- C. is negative everywhere
- D. depends on location

4

Poll

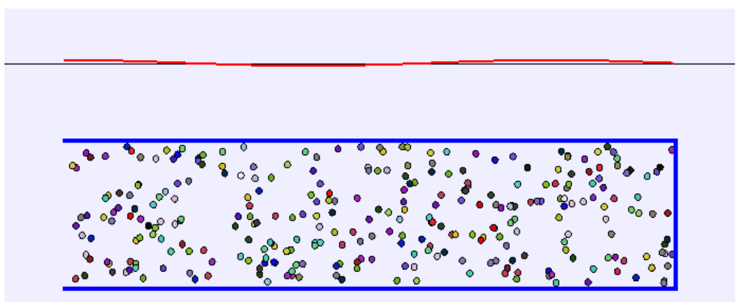


- A string is clamped at both ends and plucked so creates a standing wave. Define upward motion to be positive velocities. When the string is in position b, the instantaneous **acceleration** of points along the string
- A. is zero everywhere
- B. is positive everywhere
- C. is negative everywhere
- D. depends on location

5

Standing Sound Waves

- A long, narrow column of air, such as the air in a tube or pipe, can support a longitudinal standing sound wave.
- An open end of a column of air must be a pressure node (always at ambient pressure), thus the boundary conditions—nodes at the ends—are the same as for a standing wave on a string.
- A closed end forces a pressure antinode.



6

Musical Instruments

- With a wind instrument, blowing into the mouthpiece creates a standing sound wave inside a tube of air.
- The player changes the notes by using her fingers to cover holes or open valves, changing the length of the tube and thus its fundamental frequency:

$$f_1 = \frac{v}{2L}$$ for an open-open tube instrument, such as a flute

$$f_1 = \frac{v}{4L}$$ for an open-closed tube instrument, such as a clarinet

- In both of these equations, v is the speed of sound in the air *inside* the tube.
- Overblowing wind instruments can sometimes produce higher harmonics such as $f_2 = 2f_1$ and $f_3 = 3f_1$.

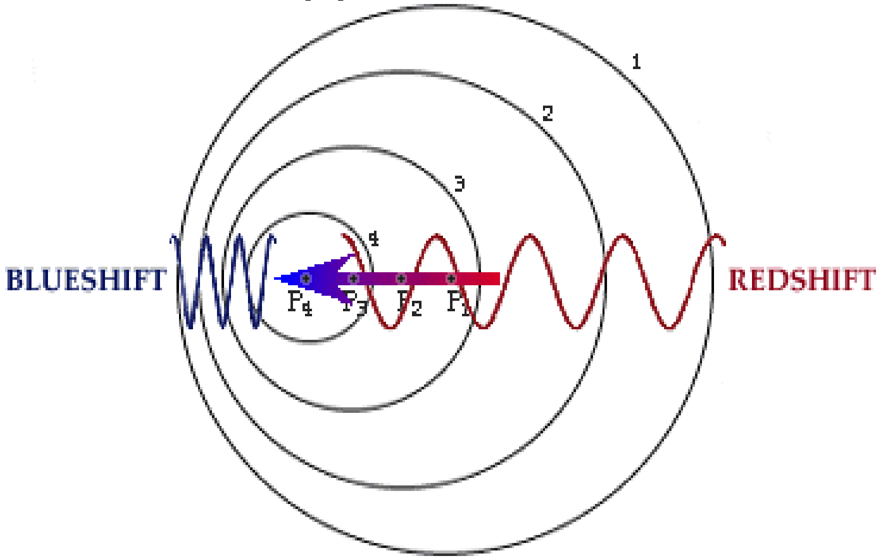
7

$$\begin{cases} \lambda_m = \dfrac{2L}{m} \\ f_m = m\dfrac{v}{2L} = mf_1 \end{cases} \quad m = 1, 2, 3, 4, \ldots \quad \text{(open-open or closed-closed tube)}$$

$$\begin{cases} \lambda_m = \dfrac{4L}{m} \\ f_m = m\dfrac{v}{4L} = mf_1 \end{cases} \quad m = 1, 3, 5, 7, \ldots \quad \text{(open-closed tube)}$$

8

Doppler Effect



9

Doppler Simulator

- Simulator: https://www.compadre.org/osp/EJSS/3858/38.htm
- 1. No Doppler Effect: red dot = Observer, black dot = source. The frequency you observe is the same as the source frequency $f_O = f_s$.
- 3. Source moves toward Observer with speed v_s. This **increases** the frequency to $f_O = f_s\, v/(v - v_s)$.
- 2: Observer moves toward Source with speed v_O. This **increases** the frequency to $f_O = f_s\,(v + v_O)/v$.
- 5: is sonic boom!

10

Doppler Effect, Section 11.10

- When the observer is stationary, and the source is moving at speed v_s directly toward or away from the observer:

$$f_{Obs} = \frac{f_s v}{v - v_s} \qquad f_{Obs} = \frac{f_s v}{v + v_s}$$

- When the source is stationary, and the observer is moving at speed v_o directly toward or away from the source:

$$f_{Obs} = (v + v_O) f_s / v \qquad f_{Obs} = (v - v_O) f_s / v$$

11

Which statement is true?

Valerie is standing in the middle of the road, as a police car approaches her at a constant speed, v_s. The siren on the police car emits a "source frequency" of f_s.

A. The frequency she observes rises steadily as the police car gets closer and closer.
B. The frequency she observes steadily decreases as the police car gets closer and closer.
C. The frequency she observes does not change as the police car gets closer.

12

Which statement is true?

Valerie is standing still as a police car approaches her at a constant speed, v_s. Daniel is in his car moving at the same constant speed, v_O, toward an identical police car which is standing still. Both hear a siren.

A. The frequency Daniel observes is lower than the frequency Valerie hears.
B. The frequency Daniel observes is higher than the frequency Valerie hears.
C. The frequencies that Daniel and Valerie observe are exactly the same.

13

Review: Instantaneous Velocity

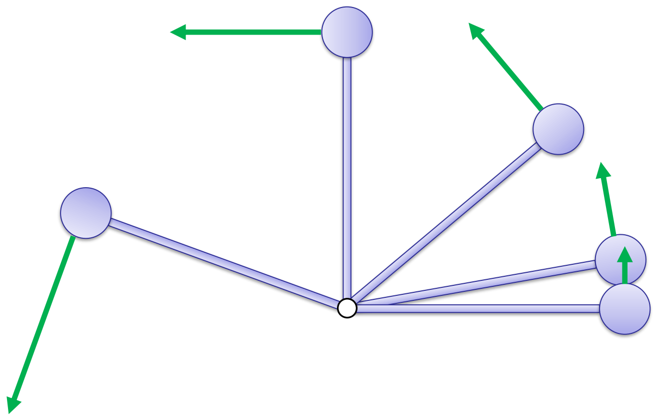
- The instantaneous velocity at time t is the average velocity during a time interval Δt centered on t, as Δt approaches zero
- In calculus, this is called *the derivative of x with respect to t*
- Graphically, $\Delta x/\Delta t$ is the slope of a straight line
- In the limit $\Delta t \rightarrow 0$, the straight line is **tangent** to the curve
- The instantaneous velocity at time t is the slope of the line that is tangent to the position-versus-time graph at time t

v = the slope of the position-versus-time graph at t

14

Review: Angular Acceleration

- Angular acceleration α is the rate of change of angular velocity.



$$\alpha \equiv \frac{\Delta\omega}{\Delta t}$$

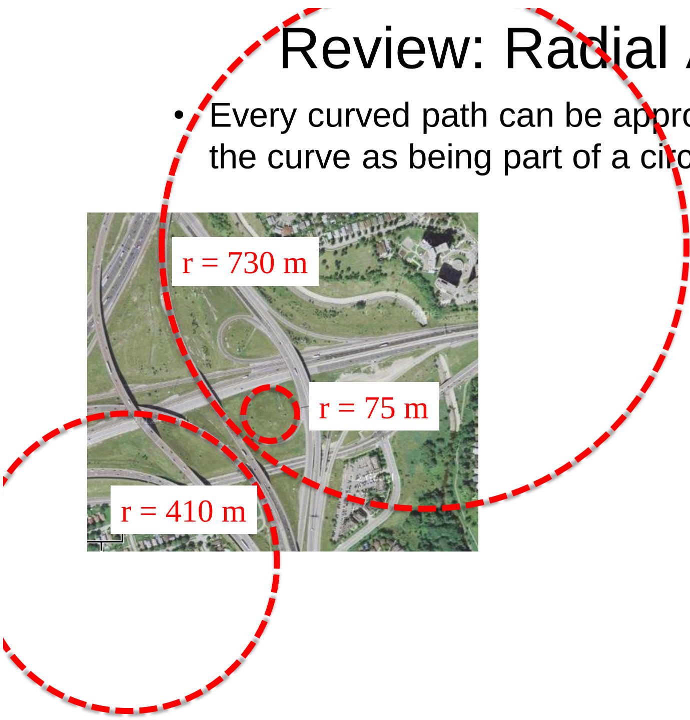
This is related to the tangential component of the acceleration:

$$a_t = \alpha r$$

15

Review: Radial Acceleration

- Every curved path can be approximated at a point on the curve as being part of a circle of radius r.



In order to stay on the curved path, the radial component of your acceleration (toward the centre of the circle) must be:

$$a_r = \frac{v^2}{r}$$

16

Review: Static Friction

- A shoe pushes on a wooden floor but does not slip.
- On a microscopic scale, both surfaces are "rough" and high features on the two surfaces touch and adhere.
- This produces force *parallel* to the surface, called the **static friction** force.
- With increased normal force, the shapes 'lock-together' better, there's more contact area, hence the maximum friction force increases.

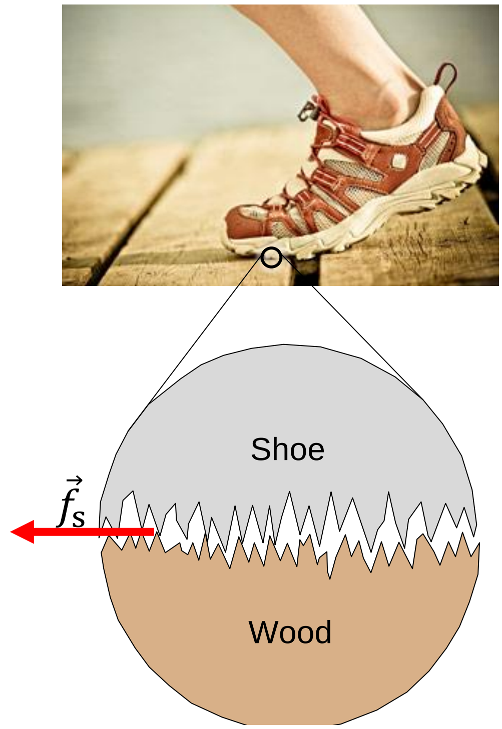


Image from http://www.which.co.uk/home-and-garden/leisure/reviews/walking-shoes/best-buy/about/

17

Gravitational Potential Energy

- It's convenient to take the zero of gravitational potential energy at infinity. Then the gravitational potential energy becomes

$$U(r) = -\frac{GMm}{r}$$

- When $r = R + y$, with $y << R$, we can redefine the zero-point of gravitational potential energy to be at $r = R$.
- Then we have an approximate equation:

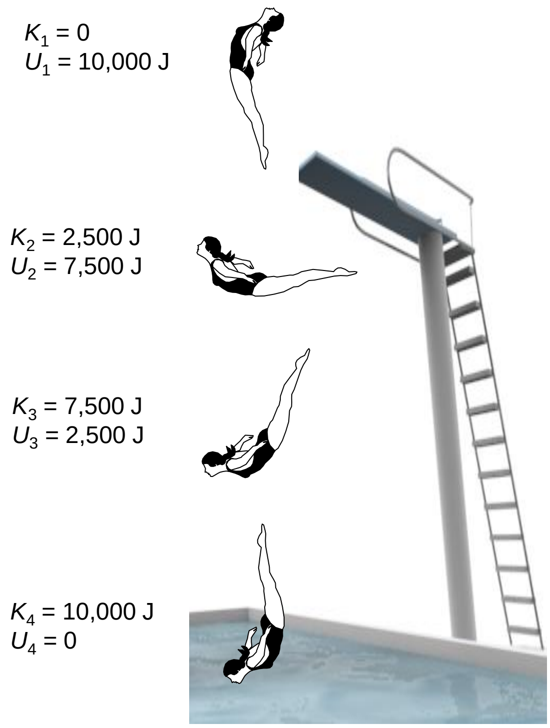
$$U \approx \frac{GMm}{R^2} y = mgy$$

- Where $g = GM/R^2$ is the acceleration due to gravity at $r = R$.

18

Review: Conservation of Mechanical Energy

$$K_1 + U_1 = K_2 + U_2$$



19

Law of conservation of momentum:

In the absence of an external force, the momentum of a system remains unchanged.

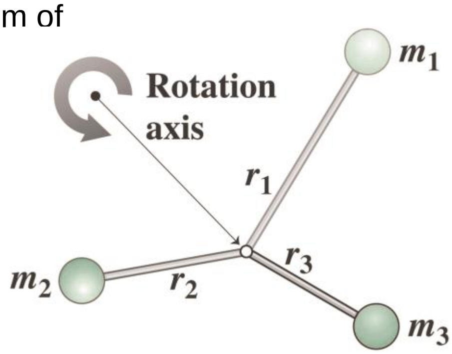
This is usually applied during brief collisions or explosions, in which internal forces are much much greater than any external forces for a short time.

20

Review: Rotational Inertia

- For a system of discrete masses, the rotational inertia is the sum of the rotational inertias of the individual masses:

$$I = \sum m_i r_i^2$$



21

Final Assessment

- There will be a Final Assessment in this course on Thursday, Dec. 17.
- You will be able to find it on Quercus under a new module called "Final Assessment"
- The format will be a 30 minute multiple-choice test, followed by a 10 minute break, then a 35 minute 2-question written answer assignment to be submitted on crowdmark.
- The timing will be as follows (all Toronto time EST):
- 7:10-7:45pm, 10 Multiple Choice Questions. The window of availability is 35-minutes, but the timer is set for 30 minutes maximum.
- 7:45-7:55 break
- 7:55-8:30pm, 2 Written Answer Questions.

22

Final Assessment

- Thursday, Dec. 17, 7:10-7:45pm, 10 Multiple Choice Questions to be done on a 30-minute timer.
- Each question will begin with a time-estimate, and these estimates will add up to be 25 minutes, just like in Midterm 5.
- Entire Course is testable: Chs.1-11 plus Practicals Material.
- Expect a slight emphasis on Chapters 4, 7, 8 and 11, as multiple-choice midterms have not been given for these chapters yet.

23

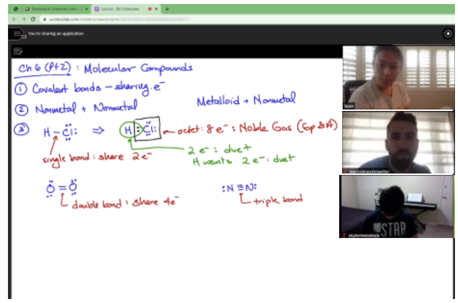
Final Assessment

- Thursday, Dec. 17, 7:55-8:30pm, 2 Written Answer Questions.
- You must follow the four-step problem solving strategy as given in Etkina and followed throughout this course, writing your answers out on the Answer Template Sheet or a reasonable facsimile.
- Each will be from one of the following five chapters:
- Ch. 5: Circular Motion
- Ch. 6: Impulse and Linear Momentum
- Ch. 9: Rotational Motion
- Ch. 10: Vibrational Motion
- Ch. 11: Mechanical Waves
- Later today I will be posting a document on Quercus in the Final Assessment Module with the five slightly different rubrics from the five above chapters.
- Each question will begin by stating the chapter, so you will know which of these five to use.

24

Study Groups – working with Peers

- Find student (students) in class that you work well with on MasteringPhysics, end-of-chapter suggested problems, and past tests.



- ***The best way to learn is to teach!*** If you can't explain to someone else what you have done, you haven't really understood it! (This is harder than you think!)

25

Tomorrow: Wacky Thursday

- At 11:10am-12:00noon tomorrow, we will have a make-up class right here for that Monday we missed in October.
- This will be an informal course review with some demonstrations for fun: "Wacky Thursday". We can do one last face filter, if you like.
- Plan to meet up with your Practical Pod tomorrow – you should be able to turn on your microphone in order to participate in the "TeamUp Quiz Bonus Course Review".
- If you cannot do the TeamUp quiz during tomorrow's class, it can be done either with your pod or on your own at any time between now and tomorrow at 11:59pm Toronto Time (it's in Module 6 right now!).

26