Preparation Notes for Chapter 13 (Simple Harmonic Motion; 2-3 classes)

Note: I have marked with ** the sections I feel to be essential. In some cases these are student presentations; if the presentation is not complete or sufficiently clear, the instructor may have to summarize the key points after the presentation. Although I have marked the problems as essential, that may be a matter of instructor's taste; the problems perhaps need not be carried through all the way to the end.

Simple Harmonic Motion and the Spring-Block System

Reading is 13.1-13.2; review questions are 13.3 and 13.9; I will probably take up at least part of 13.9 in class

(1) ** Introduction by instructor; $F \propto x$; F and x in opposite directions (restoring force) –> this is "Simple Harmonic Motion", where position is a sinusoidal function of time; $x = Acos(\omega t + \phi)$ (define constants)
(2) Discussion with class: what situations have we seen so far where force has these properties? (springs; pressure with depth; buoyant force on a floating object that is displaced)
(3) ** Student presentation on springs as examples of SHM
(4) summarize springs (if not clearly covered in presentation or no presentation on this topic): $F = -kx = ma$ –> $a = -(k/m)x$; define $\omega = \sqrt{k/m}$, so $d^2x/dt^2 = -\omega^2 x$
(5) again, if not in presentation, define period $T = 2\pi/\omega$ and frequency $f = 1/T = \omega/2\pi$; emphasize students need to know the different definitions of angular frequency, frequency, and period
(6) Discussion: suppose we have a spring with a block attached to it. We pull the spring out 5 cm and let it oscillate. Then we pull it out 10 cm and let it oscillate. How do the periods of the two situations compare? (Are the same: emphasize that for spring, period etc. only depend on k and m, not the amplitude A)
(7) ** Instructor writes down equations for v and a; discussion with class: what are the maximum values for a, v, x? point out that if you are given ω and x and v at t=0, you can solve for ϕ and A (see textbook)
(8) ** student exercise: instructor sketches $x = Acos(\omega t)$ on the board; ask them to sketch v vs. t and a vs. t; compare to neighbors, discuss; point out that x, v, a are out of phase

Q13.9 ** A 0.500 kg mass attached to a spring with a force constant of 8.00 N/m vibrates in simple harmonic motion with an amplitude of 10.0 cm. Calculate (a) the maximum value of its speed and acceleration, (b) the speed and acceleration whten the mass is 6.00 cm from the equilibrium position, and (c) the time it takes the mass to move from x=0 to x=8.00 cm.

Energy in SHM, the Pendulum, and damped oscillations

Reading is 13.3, part of 13.4, 13.6; review questions are 13.19, 13.53; I will probably take up at least part of 13.53 in class

(1) ** discussion with class of energy in block-spring system; mechanical energy conserved; $K + U = \frac{1}{2}kA^2$; point out you can use conservation of energy to determine v for any arbitrary x, assuming you know m and k

(2) ** Student presentation on pendulum clocks; also presentation on pendulum in an elevator

(3) Instructor summarizes pendulum; $F_t = -mgsin\theta = md^2s/dt^2$ where $s = L\theta$ is distance measured along arc, θ in radians (may need a bit of explaining, since we don't do circular motion); if θ is small, $sin\theta \approx \theta$ and equation becomes $d^2\theta/dt^2 = -\frac{g}{L}\theta$; so for pendulum $\omega = \sqrt{g/L}$;

(4) ** Discussion with class: two swings, one of length 3 m, the other of length 2 m. A 20 kg girl swings in the long swing; then a 40 kg boy. How do the periods of their swinging compare? What if the girl swings in the 2 m swing? point out that period depends only on L and g, not on m of bob at end of pendulum

(5) ** Student presentation on damped oscillations

(6) Instructor summarizes damped oscillations; $F_r = -bv$; $-kx - bv = ma$ or $-kx - bdx/dt = md^2x/dt^2$; complicated mathematics; solution is $x = Ad^{-bt/wm}cos(\omega t + \phi)$ and $\omega = \sqrt{k/m - (b/2m)^2}$

Q13.53 ** A large block P executes horizontal simple harmonic motion as it slides across a frictionless surface with a frequency of $f = 1.50$ Hz. Block B rests on it, as shown in Figure P13.53, and the coefficient of static friction between the two is $\mu_s = 0.600$. What maximum amplitude of oscillation can the system have if block B is not to slip? (Diagram shows block B on top of P with block P connected to a spring.)

Suggested Presentation Topics

Springs as examples of SHM (including quick lab p. 396)

How a pendulum clock works + Ch13. Q9

A pendulum in an elevator (Ch13 Q10)

A playground swing as an example of damped oscillations

The inverse pendulum (a balloon on a string)

Content of Chapter 13

definition of Simple Harmonic Motion
springs as examples of SHM
energy conservation in SHM
pendulum as example os SHM
damped oscillations

(Concept Map for Chapter 13 also available)