 Phys 2426 2016-11-03 Lec 21

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Oscillator: A system that
- Has an equilibrium
- Restoring Force
- Momentum - system "overshoots" equil.b.

Examples:
- Mass-and-spring
- Pendulum
- Guitar String
- AC Current
- Atomic Nucleus in magnetic field

Spring Oscillator

Force of Spring $|F_s| = k x_s$

x_s = stretch of spring from relaxed length

k = spring constant = strength = stiffness

Energy of Spring $U_s = \frac{1}{2} k x_s^2$

Oscillation of mass

$$x = x_{max} \sin(2\pi f t)$$

x = displacement from equilibrium

x_{max} = amplitude

f = frequency in Hz

Alternative: $\omega = 2\pi f$

$$f = \frac{1}{2\pi}\sqrt{k/m}$$

Note: sin() can be cos()

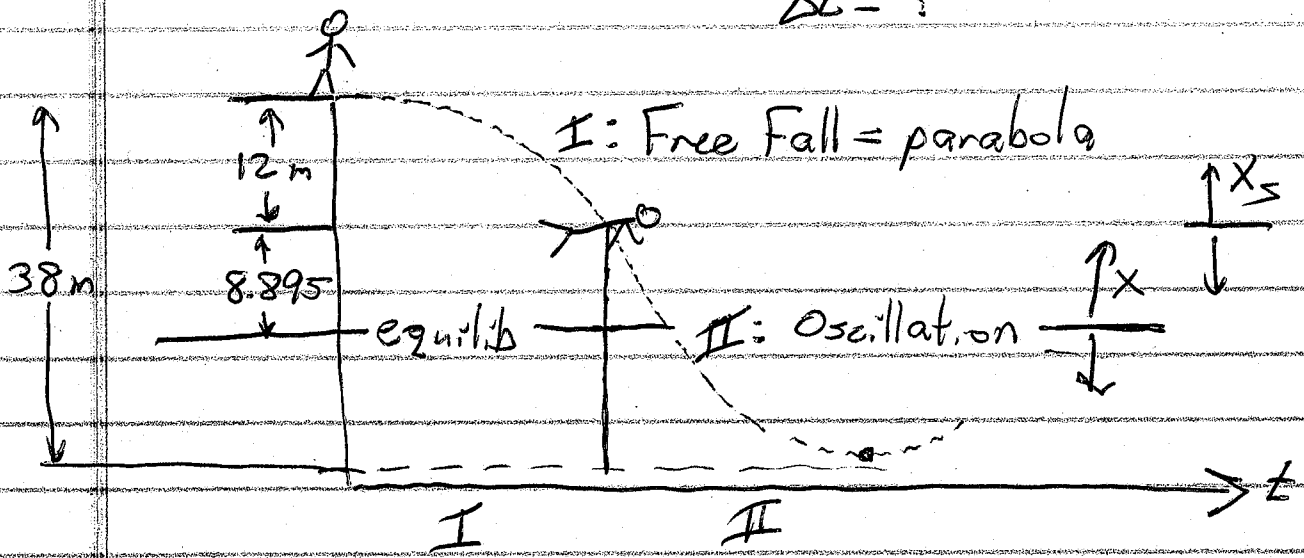
(12)

Bungee Jumper $m = 50$ kg

Bungee Length $= 12.0$ m

Bottom of Motion $= 38.0$ m

$\Delta t = ?$



I: Free Fall $\quad h = \frac{1}{2} g t^2$

$$(12) = \tfrac{1}{2}(9.8) t^2$$

$$t = 1.56 \text{ s}$$

II: Oscillation $\quad f = \frac{1}{2\pi}\sqrt{k/m}$

Need k!

Person-Spring-Earth is isolated: Cons. Energy.

Top: $\quad U_g = mgy = (50)(9.8)(38) = 18620$ J

Bottom: $\quad U_g = 0 \quad U_s = \frac{1}{2} k x_s^2$

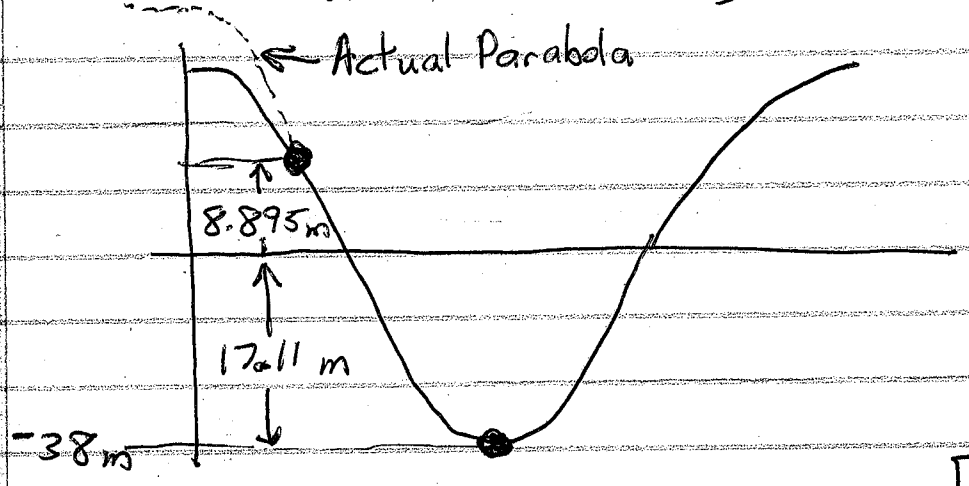
$$(18620) = \tfrac{1}{2} k (26)^2$$

$$k = 55.09 \text{ N/m}$$

(3)

Frequency $f = \frac{1}{2\pi}\sqrt{\frac{55.09}{50}} = 0.1671$ Hz

$x = x_{max}\cos(2\pi f t)$



Where is equilibrium?

$F_g = |F_s|$

$mg = kx_s$

$(9.8)(50) = (55.09)x_s$

$x_s = 8.895$ m from -12m mark

How far above bottom? $38 - 12 - 8.895 = 17.11$ m

$x = x_{max}\cos(2\pi f t)$

First Dot: $8.895 = 17.11\cos(2\pi f t)$

$\frac{8.895}{17.11} = 0.5199 = \cos(2\pi f t)$

$\arccos(0.5199) = 1.024 = 2\pi f t$

$t = 0.9753$ s

Second Dot: $t = T/2 = 1/2f = 2.992$ s

$\Delta t = 2.017$ s

Total Time $= (1.56) + (2.02) = 3.58$ s

(5)

Maximum Velocity?

Top $v=0$

12 m $\quad mg\Delta y = (50)(9.8)(-12\,m) = -5880\,J$

$\frac{1}{2}mv^2 = K$

$\frac{1}{2}(50)v^2 = 5880\,J$

$v = 15.3 \quad m/s$

Equilib From bottom to equilib

$\Delta U_g = mg\Delta y = (50)(9.8)(17.11) = 8384\,J$

$\Delta U_s = U_{sf} - U_{si} = 0 - \frac{1}{2}kx_s^2$

$= -\frac{1}{2}(55.09)(17.11)^2 = -8064\,J$

↖ not!

$\Delta U = 320\,J$

Max velocity $\quad x = x_{max}\cos(2\pi ft)$

$v = x_{max}\,2\pi f(-\sin(2\pi ft))$

$v_{max} = 17.11\,2\pi f = 17.96 \quad m/s$