 Phys 1402 2016-11-03 Lec 21

Oscillations - any system oscillates if it has an equilibrium (natural state where it can rest), if it tends toward equilibrium, and if it overshoots the equilibrium.

Technically: equilibrium
restoring "force"
momentum

Typical Oscillators:
- Mass-on-a-spring
- Pendulum
- Rocking boat/chair
- Pieces of Waves
- Molecules
- Nuclei in magnetic fields

Spring Oscillator

Force of Spring: $|F_s| = k\,x_s$

x_s = "stretch" of spring from its natural length

k = spring constant, "strength", "stiffness"

Energy of a Spring $(\text{Energy})_s = PE_s = \frac{1}{2}k\,x_s^2$

Note: Energy is always ⊕

Oscillation of spring

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

x = displacement from equilibrium

x_{max} = Amplitude

f = frequency in $\left(\text{cycles}/s = Hz\right)$

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

Note: $\sin()$ can be $\cos()$.

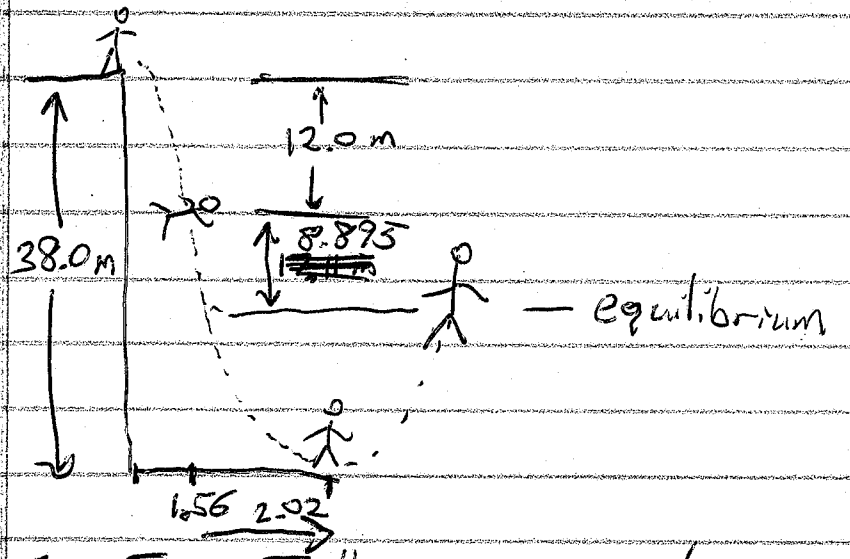
(2)

Bungee Jumper $m = 50$ kg

Cord Length = 12.0 m

Lowest point after jump = 38.0 m

Δt to bottom?



I: Free Fall $g = 9.8\ m/s^2$

$$h = \frac{1}{2} g t^2 \qquad (12.0) = \frac{1}{2}(9.8) t^2$$

$$t = \sqrt{\frac{2 \cdot (12.0)}{9.8}} = 1.56\ s$$

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

$m = 50$ kg

$k = ?$

Gravitational Energy $PE_g = mgy$

$(50)(9.8)(38) = 18620\ J$

Spring Energy

(9)

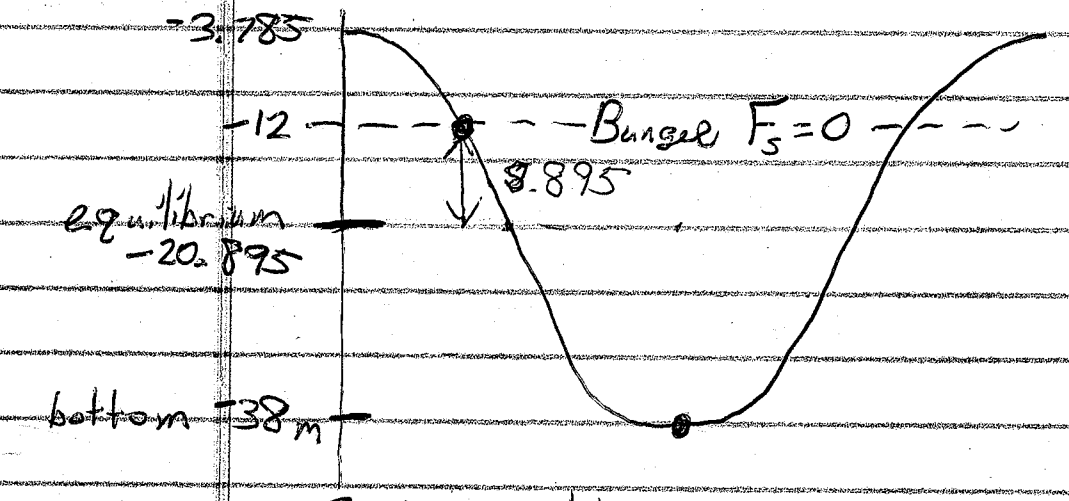
Spring Energy $PE_s = \frac{1}{2}kx_s^2$

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

$x_s = 38 - 12$

$k = \frac{2(18620)}{(26)^2} = 55.09 \text{ N/m}$

$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = 0.1671 \text{ Hz}$



To find Equilibrium:

$mg = F_s = |F_s| = kx_s$

$(9.8 \text{ N/kg})(50 \text{ kg}) = (55.09)x_s$

$x_s = \frac{(9.8)(50)}{55.09} = 8.895 \text{ m} = \text{stretch}$ (9) equilib

Amplitude $= 38 - 20.895 = 17.11 \text{ m}$

(5)

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

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

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

$$\cos^{-1}(0.5199) = 1.024 = 2\pi(0.1671)t$$

First Dot: $t = 0.9753$ s

Second Dot: $\frac{T}{2} = \frac{1}{2f} = 2.992$ s

} Δt

$$\Delta t = 2.017 \text{ s}$$

Top to Bungee: 1.56 s

Bungee to bottom: 2.02 s

Top to Bottom: 3.58 s

~~3601 445 = 5602~~