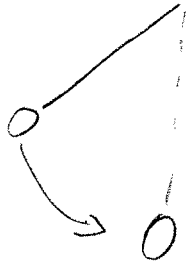
Physics 10154 - Exam #3c

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work (or if some parts are incorrect) even if you get the right answer. Clearly indicate your answer with a circle or box and remember to include correct units and significant figures.

1. (40 pts) A pendulum bob of mass M drops from rest at a height of 0.45 meters above the lowest point of its motion. The length of the pendulum string is 1.2 meters. At the low point in its motion, the mass M collides with another mass 2M initially at rest. The masses stick together and swing upwards.

What angle does the pendulum string make with the vertical when the combined mass reaches its maximum height?

Part 1 : drop



$\Sigma W_F = W_T + W_c + W_g = \frac{1}{2}mv^2 - 0$

$0 + 0 + mgh = \frac{1}{2}mv^2$

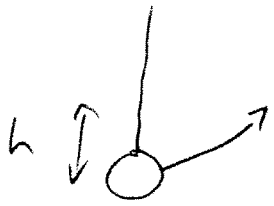
$v = \sqrt{2gh} = 2.97\ m/s$

Part 2 : collision

$M(2.97) + 2M(0) = 3M v_f$

$v_f = \frac{2.97}{3} = 0.99\ m/s$

Part 3 : rise



$W_T + W_c + W_g = 0 - \frac{1}{2}mv_0^2$

$0 + 0 - mgh = -\frac{1}{2}mv_0^2$

$h = \frac{v_0^2}{2g} = .05\ m$

$h = L - L\cos\theta$

$.05 = 1.2(1 - \cos\theta)$

$.0417 = 1 - \cos\theta$

$\cos\theta = .958$

$\theta = 17^\circ$

2. (30 pts) A merry-go-round has a radius of 1.5 meters. It accelerates tangentially at a rate of 0.45 meters/sec^2 from rest. A child of mass 45 kg is only able to stay on the merry-go-round as long as static friction between his shoes and the platform allows. The coefficient of static friction here is 0.86.

Through how many revolutions does the merry-go-round travel before static friction is not sufficient to keep the child on the platform?

Threshold problem

Side view

$$\Sigma F_{rad} = \frac{mv^2}{r} - \mu_s mg = 0$$

$$\frac{v^2}{r} = \mu_s g \qquad v = \sqrt{\mu_s g r}$$

$$= \sqrt{(.86)(9.8)(1.5)}$$

$$= 3.56 \text{ m/s}$$

$$v^2 = v_0^2 + 2a\Delta s$$

$$(3.56)^2 = 0 + 2(.45)\Delta s$$

$$\Delta s = 14.05 \text{ m}$$

$$\Delta\theta = \frac{\Delta s}{r} = 9.36 \text{ rad} \cdot \frac{1 \text{ rev}}{2\pi \text{ rad}} = \boxed{1.5 \text{ rev}}$$

3. (30 pts) A satellite is in orbit with a speed of 11,000 miles/hour.

a) What is the orbital period of the satellite?
b) What is the altitude of the satellite about Earth's surface?

$$V = 11{,}000 \frac{mi}{hr} = 4916 \ m/s$$

$$v^2 = \frac{GM}{r} \qquad r = \frac{GM}{v^2}$$

$$= \frac{(6.676 \times 10^{-11})(5.98 \times 10^{24})}{(4916)^2}$$

$$= 1.65 \times 10^7 \ m$$

$$T = \frac{2\pi r}{v} = \frac{2\pi (1.65 \times 10^7)}{(4916)} = \boxed{2.11 \times 10^4 \ s}$$

or 5.86 hrs

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6) $h = r - R_E$

$$= 1{,}65 \times 10^7 - 6.38 \times 10^6$$

$$= \boxed{1.012 \times 10^7 \ m}$$

or 6300 mi