Name Solutions

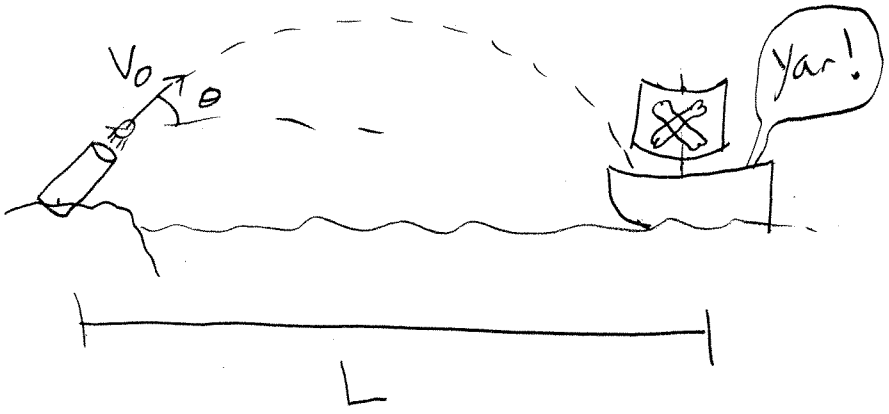
Exam #1
Physics 247
October 5, 2005

Each problem is worth 25 points

Problem	Score
1	
2	
3	
4	
Total	

1. A pirate ship is 560m from a fort at the harbor entrance of an island. A defense cannon, located at sea level, fires balls at initial speed $v_0 = 82m/s$.

   At what angle θ_0 from the horizontal must a ball be fired to hit the ship?



$$y = y_0 + (V_0 \sin\theta)\, t_{hit} - \frac{1}{2} g t_{hit}^2 \qquad y = y_0 = 0$$

$$\Rightarrow \quad t_{hit}\left(V_0 \sin\theta - \frac{1}{2} g t_{hit}\right) = 0$$

$$\Rightarrow \quad t_{hit} = \frac{2 V_0 \sin\theta}{g}$$

$$L = V_0 \cos\theta\, t_{hit} = \frac{2 V_0^2}{g} \cos\theta \sin\theta = \frac{V_0^2 \sin 2\theta}{g}$$

$$\Rightarrow \quad \sin 2\theta = \frac{gL}{V_0^2} \quad \Rightarrow \quad 2\theta = \sin^{-1}\left(\frac{gL}{V_0^2}\right)$$

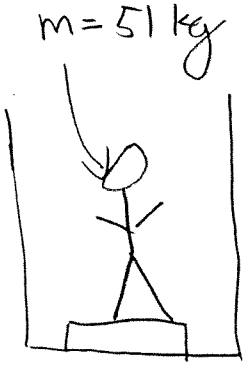
$$\boxed{\theta = 27.4^\circ}$$

But can also shoot at $\theta = 90 - 27.4$, i.e.

$\sin(2(27.4)) = \sin(2 \cdot (90 - 27.4))$

so also $\boxed{\theta = 62.6^\circ}$

2. A 51 kg person is standing on a scale in an elevator in the earth's gravitational field ($g = 9.8$ m/s^2). What is the reading on the scale when



(a) the elevator is moving upwards at a steady speed of 1 m/s?

$F_N - mg = ma$

But $a = 0$ ← constant velocity!

$\Rightarrow F_N = mg = \boxed{500\ N}$

(b) the elevator is accelerating upwards at 1.96 m/s^2?

$F_N - mg = ma$

$F_N = m(g + a) = \boxed{600\ N}$

(c) the elevator falls down the elevator shaft due to its cable being severed?

$F_N - mg = ma$

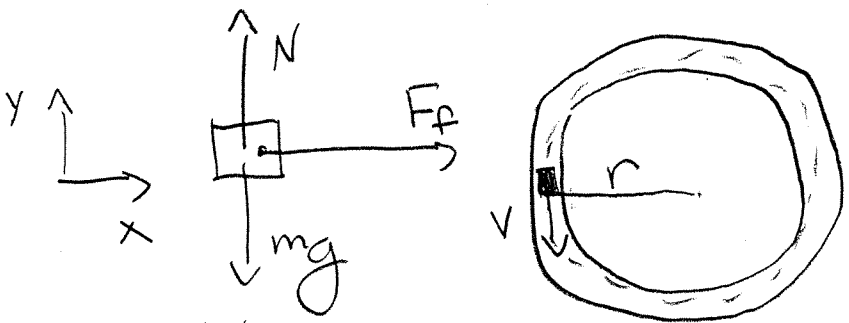
But falling $\Rightarrow a = -g$

$\Rightarrow \boxed{F_N = 0}$

3. A 1000 kg car rounds a bend of 100 m radius at a speed of 36 km/hr, without slipping or skidding.

(a) Find the frictional force acting between the tires and the road.

$36 \frac{\text{km}}{\text{hr}} \cdot \frac{1\,\text{hr}}{3600\,\text{s}} \cdot \frac{1000\,\text{m}}{1\,\text{km}} = 10\ \text{m/s}$



Side View Top View

y: $N - mg = 0$

$N = mg$

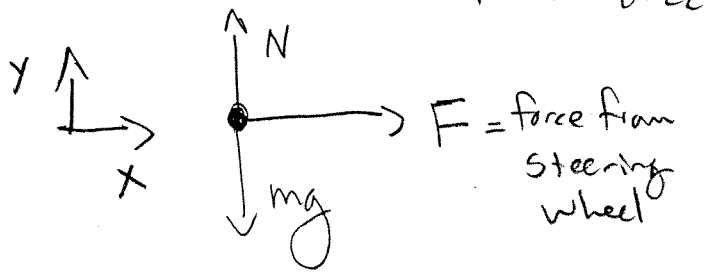
x: $F_f = ma_c$

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

$F_f = \frac{mv^2}{r} = \boxed{1000\ \text{N}}$

(b) The car has slick leather seats and the 50 kg driver has slick leather pants, so friction can be neglected between the driver and her seat. How much force must the driver apply to the steering wheel in order to not slide on the seat?

Driver must go in circle ⇝ accelerates inward with acceleration $a_c = \frac{v^2}{r}$



Driver

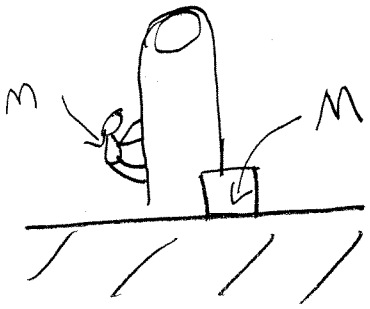
y: $N - mg = 0$

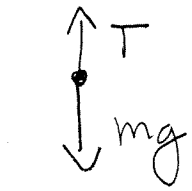
x: $F = ma_c$

$\Rightarrow F = \frac{mv^2}{r} = \boxed{50\ \text{N}}$

4. A 10 kg monkey climbs up a massless rope that runs over a frictionless tree limb and back down to a 15 kg package on the ground.

(a) What is the magnitude of the least acceleration the monkey must have if it is to lift the package off the ground?





Monkey

Box

Monkey

$T - mg = ma$

$T = m(g+a)$

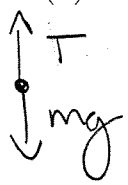
Box $T + N - Mg = 0$

When Box is lifted up, $N = 0$ & the acceleration of the box is zero. Plugging in for T:

$m(g+a) - Mg = 0 \Rightarrow a = \frac{(M-m)g}{m} = \boxed{4.9\ m/s^2}$

If after the package has been lifted, the monkey stops its climb and holds onto the rope, what is

(b) the magnitude and direction of the monkey's acceleration?



Monkey

Box

Box and Monkey have the same acceleration a

Monkey $T - mg = ma$, $T = mg + ma$

Box $T - Mg = -Ma$, $T = Mg - Ma$

$\Rightarrow Mg - Ma = mg + ma \Rightarrow a = \left(\frac{M-m}{M+m}\right)g = \boxed{1.96\ m/s^2}$

(c) the tension in the rope?

$T = mg + ma = \left(\frac{2mM}{m+M}\right)g = \boxed{117.6\ N}$