Circular Motion: problems from our activities and workbook

1. A car with a mass of 1000 kg is going around a flat curve with a radius of 80 m.

a. what happens to the car if the driver tries to take the curve too fast? Describe how the car skids.

b. what is the maximum safe speed at which the car can negotiate the curve if the coefficient of static friction between tires and road is 0.85? If it is 0.37?

2. A swing ride at a carnival consists of chairs that are swung in a circle by 12 m long cables attached to a vertical rotating pole. Suppose that the total mass of a chair and its rider 220 kg, and that the cable makes a 65^0 angle to the pole. Find

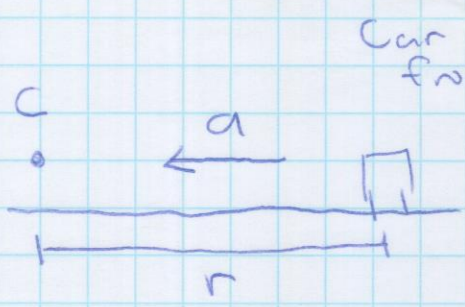
a. the radius of the circle made by the rider
b. the tension in the cable
c. the speed of the rider
d. the time it takes the rider to make one complete rotation

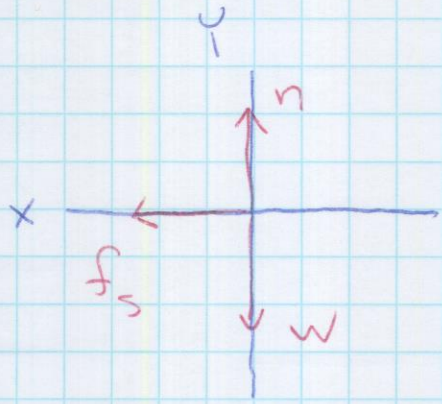
3. A coin of mass m is placed at a distance of 30 cm from the center of a turntable. The coefficient of static friction between coin and turntable is 0.45. Starting from rest, the turntable is rotated faster and faster. At what rotation frequency does the coin slip?

4. The Daytona 500 is a major event of the NASCAR season. It is held at the Daytona International Speedway in Daytona, Florida. The turns in this track have a maximum radius of 316 m and are steeply banked at 31^0 to the horizontal. At what speed should a driver take this turn in icy conditions, when the road surface is frictionless?

5. Daytona, Florida does not often have icy conditions. Suppose that the coefficient of static friction between tires and road is 0.60. What is the maximum speed at which a 900 kg car can take this curve?

1.





$\Sigma F_x = ma_x$

$f_s = m\left(\frac{v^2}{r}\right)$

$\mu_s n = m(v^2/r)$

$\mu_s (mg) = m\, v^2/r$

$v^2 = \mu_s g r$

$\Sigma F_y = ma_y$

$n - w = 0$

$n = mg$

$\mu_s = 0.85$: $\quad v = \sqrt{(0.85)(9.8)(80)}$

$v = 25.8$ m/s

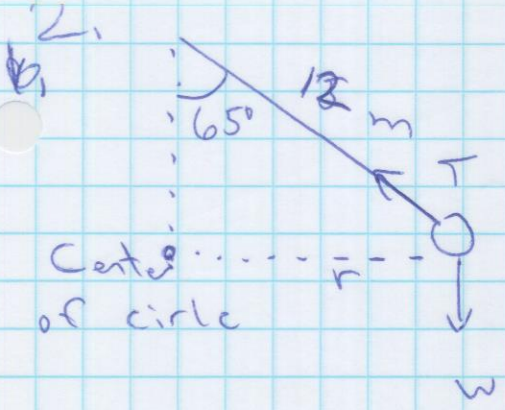
$\mu_s = 0.37$: $\quad v = \sqrt{(0.37)(9.8)(80)}$

$v = 17.$ m/s

Why does mass not matter? Shouldn't heavier vehicle do better?

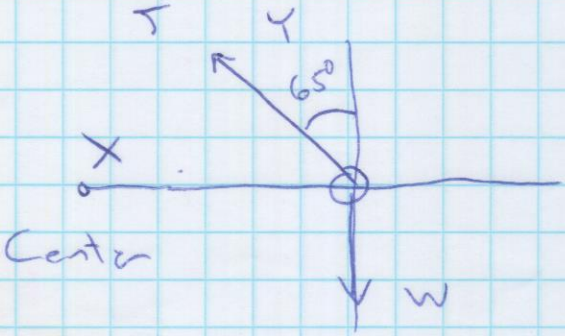
Important point: $F_c = mv^2/r$ is force car needs. Not force it generates

2.



$\sin 65^\circ = r/12$

$r = 11 \text{ m}$



$\Sigma F_x = ma_x$

$T \sin 65^\circ = ma_c$

$T \sin 65^\circ = \frac{mv^2}{r}$

$\Sigma F_y = ma_y$

$T \cos 65^\circ - w = 0$

$T \cos 65^\circ = mg$

$T = mg / \cos 65^\circ$

$T = \frac{(220)(9.8)}{\cos 65^\circ}$

$T = 5100 \text{ N}$

$5100 \sin 65^\circ = \frac{220 v^2}{11}$

$v = 15 \text{ m/s}$

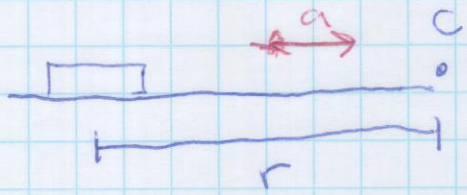
$2\pi r = vT$

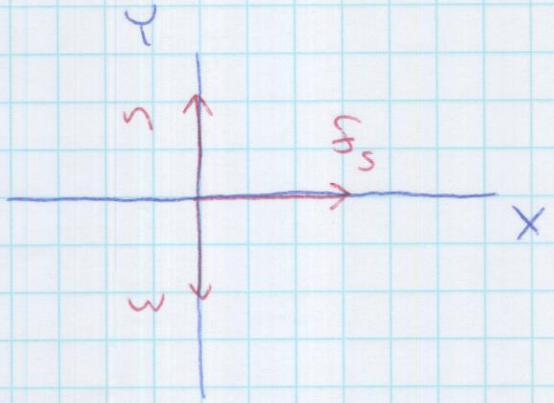
$T = \frac{2\pi(11)}{15} = 4.6 \text{ s}$

DISCUSSION

- Can string be perfectly horiz
- Why flatten

3.





$\Sigma F_x = ma_x$

$f_s = ma_x$

$\mu_s n = m(v^2/r)$

$\mu_s mg = mv^2/r$

$v = \sqrt{\mu_s g r}$

$\Sigma F_y = ma_y$

$n - w = 0$

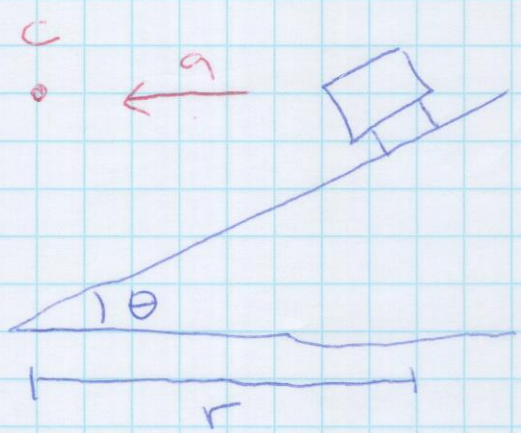
$n = mg$

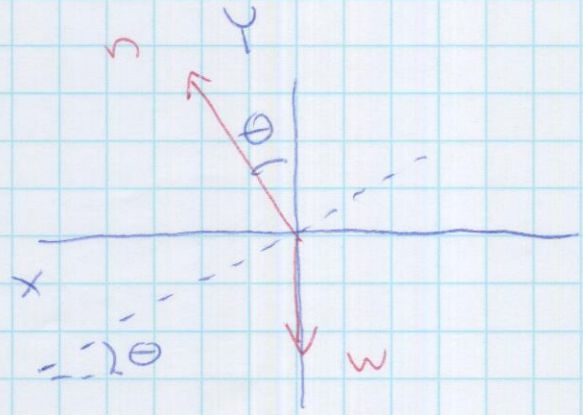
and $T = \frac{2\pi r}{v}$ or $f = \frac{v}{2\pi r}$

$f = \frac{\sqrt{\mu_s g r}}{2\pi r} = \frac{1}{2\pi}\sqrt{\frac{\mu_s g}{r}}$

$f = \frac{1}{2\pi}\sqrt{\frac{(0.45)(9.8)}{0.30}}$

freq = 3.8 rev / sec

4. 



No friction. radius cannot get larger than 316 m or you are off the track.

Your balls in bowls: slide INWARD if v is too low, OUTWARD if too high.

So solving for "Right" speed to stay in your lane.

$$\Sigma F_x = ma_x \qquad \Sigma F_y = ma_y$$

$$n\sin\theta = ma_c \qquad n\cos\theta - w = 0$$

$$n = \frac{mg}{\cos\theta}$$

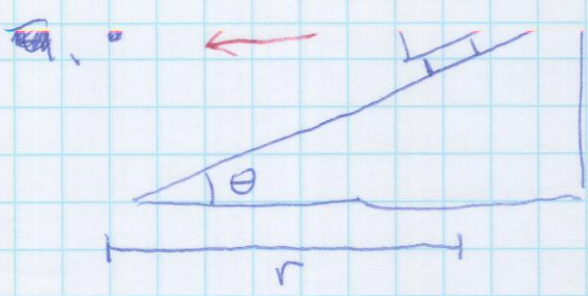
$$\frac{mg}{\cos\theta}\sin\theta = \frac{mv^2}{r}$$

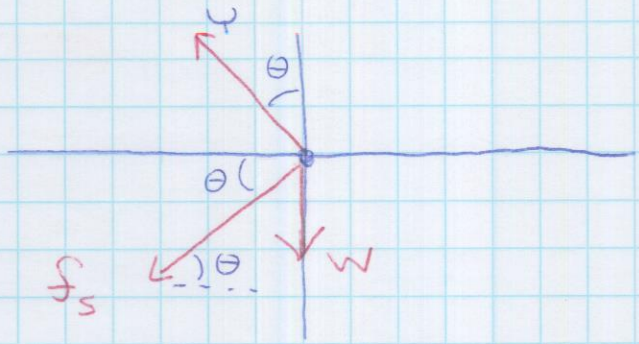
$$g\tan\theta = v^2/r$$

$$v^2 = rg\tan\theta$$

$$v = \sqrt{(316\text{ m})(9.8\text{ m/s})\tan 31^\circ}$$

$$v = 43\text{ m/s}$$





Max speed. Car tends to slide outward as you speed up. f_s holds it in lane. (as long as it can!)

$\Sigma F_x = ma_x$

$f_s \cos\theta + n \sin\theta = mv^2/r$

$\Sigma F_y = ma_y$

$n \cos\theta - w - f_s \sin\theta = 0$

$n \cos 31 - \mu_s n \sin 31 = mg$

$n [\cos 31 - 0.6 \sin 31] = (900)(9.8)$

$n = 16095$ N

$\mu_s n \cos 31 + n \sin 31 = mv^2/r$

$(0.6)(16095)\cos 31 + (16095)\sin 31 = \frac{900 v^2}{316}$

$v = 76$ m/s

1 mph = 0.447 m/s

2.237 mph = 1 m/s

76 m/s = 170 mph