Strings and Tension
PHYS 2425

Phil Alcorn

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1. Conceptual Questions

A. A block rests on a merry-go-round that is spinning at a constant angular speed. What role does friction play in keeping the block moving in a circle?

The block provides the centripetal force required to maintain circular motion.

B. A ball is attached to a string and whirled in a horizontal circle so that the string makes an angle θ with the vertical (a conical pendulum). Why is the vertical component of the tension not "wasted," even though it doesn't contribute to the circular motion?

The vertical component is required to balance the force of gravity and maintain horizontal motion.. Without sufficient vertical vertical force the ball would accellerate downward.

C. If the the same ball decreases its radius, what must have happened to its speed?

The ball must have slowed down.

D. Suppose there is a conical pendulum whose angle relative to the vertical axis is approaching 90°. What prevents the angle from actually reaching 90°?

If the angle were 90°, then the string would have no vertical component. This means that gravity would cause a negative vertical acceleration, lowering the angle of the ball. Of course this also means that the ball would never reach 90° in the first place.

2. Newton's Laws

A. A small ball with mass $m = 0.5kg$ is attached to a physics string, $L = 1.2m$ and moves in a steady horizontal circle. (A conical pendulum.) The string makes an angle of $\theta = 30^\circ$ with the vertical axis. Find the ball's (i) speed, (ii) angular speed ω, (iii) period T, and (iv) tension $\vec{T}$.

We know the $L\sin(\theta)$ gives the radius. Balancing forces gives

$$\vec{T}\cos(\theta) = mg$$

$$\vec{T}\sin(\theta) = \frac{mv^2}{r}$$

Eliminating $\vec{T}$ gives:

$$\frac{v^2}{r} = g\tan(\theta)$$

We also know $\omega = \frac{v}{r}$ and period $T = \frac{2\pi}{\omega}$.

Using the formula we derived, we can see $v = 1.843\frac{m}{s}$, angular speed $\omega = 3.07\frac{rad}{s}$, period $T = 2.05s$, and the tension $\vec{T} = 5.662N$.