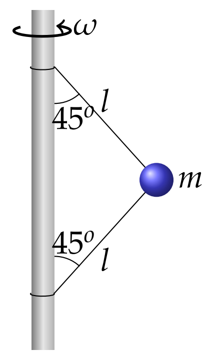
Physics 24a
Forces and Equations of Motion
Monday, February 8, 2016

3.{5, 12, 17, 22, 25}

1 - Mass and Axle* - 3.5 A mass m is connected to a vertical revolving axle by two strings of length l, each making an angle of 45^o with the axle, as shown. Both the axle and mass are revolving with angular velocity ω. Gravity is directed downward.

(a) Draw a clear force diagram for m.

(b) Find the tension in the upper string, T_{up}, and the lower string T_{low}.



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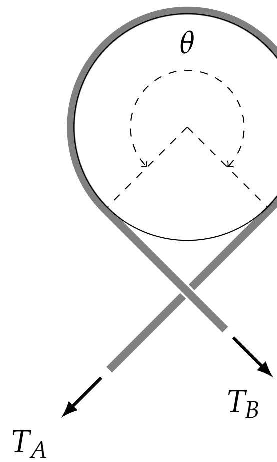
2 - Capstan - KK 3.12 A device called a capstan is used aboard ships in order to control a rope which is under great tension. The rope is wrapped around a fixed drum, usually for several turns (the drawing shows about a three-quarter turn). The load on the rope pulls it with a force T_A, and the sailor holds it with a much smaller force T_B. Show that $T_B = T_A e^{-\mu\theta}$, where μ is the coefficient of static friction and θ is the total angle subtended by the rope on the drum.



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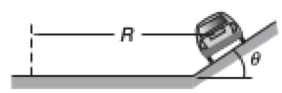
3 - Turning car* - KK 3.17 A car enters a turn whose radius is R. The road is banked at angle θ, and the coefficient of friction between the wheels and the road is μ. Find the maximum and minimum speeds for the car to stay on the road without skidding sideways.



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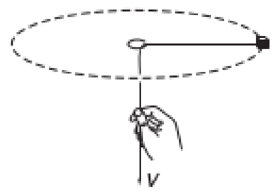
4 - Mass, string, and ring* - KK 3.22 A mass m whirls around on a string which passes through a ring, as shown. Neglect gravity. Initially the mass is distance r_0 from the center and is revolving at angular velocity ω_0. The string is pulled with constant velocity V starting at $t = 0$ so that the radial distance to the mass decreases. Draw a force diagram and obtain a differential equation for ω. This equation is quite simple and can be solved either by inspection or by formal integration. Find

(a) $\omega(t)$.

(b) The force needed to pull the string.



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5 - Hovercraft - KK 3.25 The Eureka Hovercraft Corporation wanted to hold hovercraft races as an advertising stunt. The hovercraft supports itself by blowing air downward, and has a big fixed propeller on the top deck for forward propulsion. Unfortunately, it has no steering equipment, so the pilots found that making high speed turns was very difficult. The company decided to overcome this problem by designing a bowl-shaped track in which the hovercraft, once up to speed, would coast along in a circular path with no need to steer.

When the company held their first race, they found to their dismay that the craft took exactly the same time T to circle the track, no matter what its speed. Find the equation for the cross-section of the bowl in terms of T.

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