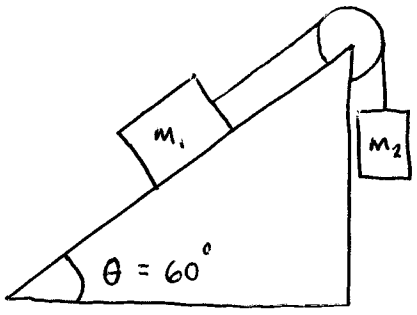
Exam 1

(1)



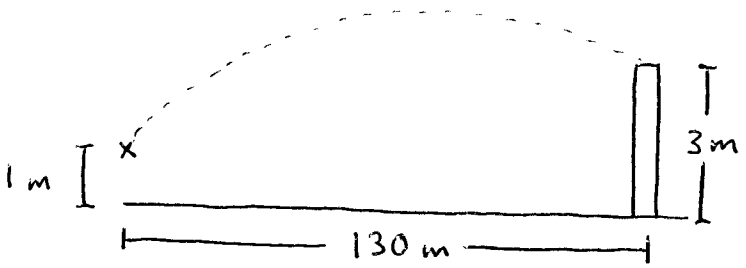
$m_1 = 20$ kg

$m_2 = 10$ kg

$\mu_K = 0.2$

Compute the acceleration of m_2 (magnitude & direction) and the tension in the string.

(2)

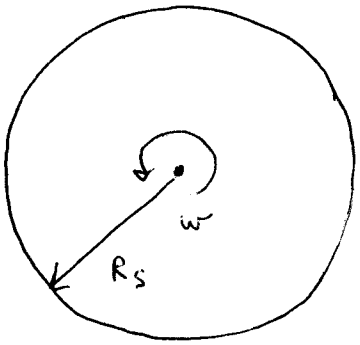


With what <u>minimum</u> speed must the batter strike the ball to clear the 3 m home run fence?

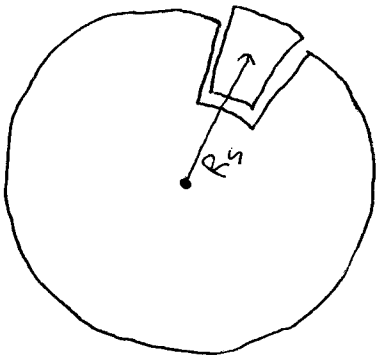
(3) San Diego is 450 miles due west of Tucson. You fly from Tucson to San Diego in an aircraft whose airspeed is 500 mph. There is a southerly wind of 100 mph. How long does it take you to reach San Diego?

④ When a massive star dies violently in a supernova explosion it leaves behind a small, hot, dense, rapidly-spinning cinder that was once the core of the star. This remnant is called a pulsar (named for the radio pulse it emits once per revolution). Roughly half the mass of the original star is compressed into a ball 10 km in radius (1 cm^3 of the pulsar would weigh a billion tons).

As the pulsar ages it cools and slows down, eventually coming to a halt. It can later be spun back up to high rotational speeds, however, if it meets up with another star and begins sucking matter from it with its intense gravitational field. There is a limit, though, to how fast the star can be spun back up:



$\omega < \omega_{critical}$



$\omega = \omega_{critical}$

If the pulsar rotates too rapidly its intense gravitational field will be unable to hold itself together and the star will fly apart. The pulsar reaches this critical ω

when an arbitrary piece of the star's mass comes unstuck and loses contact with the star as shown above (note that when this happens the pulsar's surface ceases to exert a normal force on the broken-away piece).

(a) Using a free-body diagram (on the broken-away piece) and the 2nd Law, compute $\omega_{critical}$. Use R_{star} = 10 km, $M_{star} = 4 \times 10^{30}$ kg, and $G = 6.67 \times 10^{-11} \frac{m^3}{kg\ s^2}$. Take $m_{piece} = m << M_{star}$.

(b) What upper limit does this place on the frequency of radio pulses from the star (in Hz)?

(c) What would be the linear velocity v of a ant sitting on the surface of the star (note that C, the speed of light, = 3×10^8 m/s). What fraction of the speed of light is this?

Formula Sheet

$$X = X_0 + V_0 t + \frac{1}{2} a t^2$$

$$V = V_0 + a t$$

$$V^2 = V_0^2 + 2a(x - x_0)$$

$$a_c = \frac{V^2}{R} = \omega^2 R$$

$$\omega = 2\pi f = \frac{2\pi}{T}$$

$$f = \frac{1}{T} \; ; \; R\omega = V$$

$$F_{Gravity} = \frac{G M_1 M_2}{R_{12}^2}$$

$$\sum \vec{F} = m\vec{a}$$