Chapter E - Problems

Blinn College - Physics 2425 - Terry Honan

Problem E.1

(a) What is the centripetal (radial) acceleration of a point on the earth's equator?

(b) Give an expression for the centripetal acceleration as a function of the latitude angle, θ_L. What is this at the latitude of Bryan, Texas, at $\theta_L = 30.7\,°$?

(c) What are the speeds of a point at the equator and at Bryan, Texas due to the eaarth's rotation?

(d) The earth's rotation is slowing at a rate of 2.2 s every 100,000 years..

$$\frac{dT}{dt} = \frac{\Delta T}{\Delta t} = \frac{2.3\text{ s}}{100{,}000\text{ years}}$$

What is the (very small) tangential component of the acceleration of a point on the earth's equator? Hint: use the chain rule.

$$\frac{d}{dt}\frac{2\pi r}{T} = -\frac{2\pi r}{T^2}\frac{dT}{dt}$$

Problem E.2

A car drives around a 200 m radius circle with a speed that decreases uniformly from 30 m/s to 20 m/s in 8 s. At the instant the speed is 25 m/s then:
(a) what is the centripetal acceleration,
(b) what is the tangential acceleration and
(c) what is the magnitude of the acceleration?

Problem E.3

While moving in a circle with a 12 m radius the speed of a particle varies with time by $v(t) = 2 + 10\,t - 4\,t^2$ in SI units. At $t = 2$ s what are the centripetal and tangential components of th acceleration? Also give the magnitude of the total acceleration and the angle of this acceleration measured relative to the centripetal direction.

Problem E.4

In the Bohr model of the hydrogen atom an electron moves in a circle of radius 5.29×10^{-11} m with a speed of $2.20\times10^{6}\,m/s$. What net force is needed to produce this motion.

Problem E.5

A small block sits on a turntable that rotates with a period of 3 s. If the coefficient of static friction between the turntable and the block is 0.4 then what is the largest distance the block can be from the center without slipping?

Problem E.6

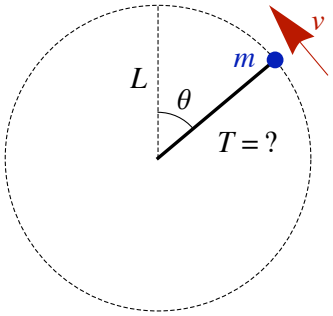
A Ferris Wheel has a radius of 30 m and rotates once every 40 s. What are the minimum and maximum normal force of the seat on a 160 lb man. A Ferris wheel rotates in a vertical circle and a rider always sits upright.

Problem E.7

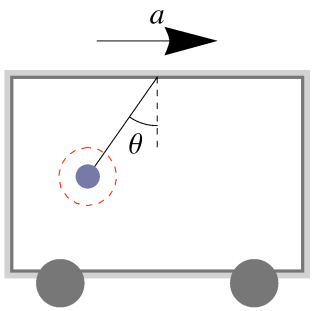
A mass m is moves in a vertical circle at the end of a string of length L.
(a) If at the bottom the mass has a speed v then what is the tension T in the string?
(b) If at the top the mass has a speed v then what is the tension T in the string? What is the minimum speed the mass can have without the string losing its tension?

Problem E.8

A mass m is moves in a vertical circle at the end of a string of length L. If the mass has a speed v, at angle θ measured from vertical as shown, then what is the tension T in the string at that position. Also, find the tangential componet of the acceleration at that position.



Problem E.9



We saw in the Chapter D notes that a pendulum in an accelerating cart will hang at an angle given by

$$\tan\theta = \frac{a_c}{g}.$$

Treating the accelerating cart as an accelerating frame reanalyze the problem to derive the same result. What is the tension in the string?

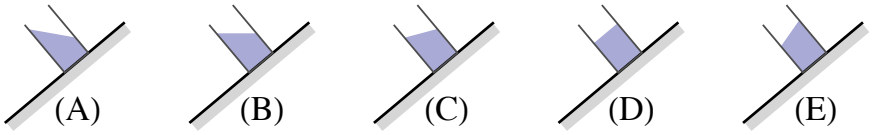
Problem E.10

This is an extension of problem E.1. Define *true vertical* to be the direction pointing toward the center of the earth and assume the earth is a perfect sphere. A plumb bob will not hang in the direction of true vertical but will hang in the dirction of the effective gravity $\vec{g}_{\text{eff}}$. The latitude of Bryan Texas is $\theta_L = 30.7\,°$.

(a) What is the strength of the effective gravity g_{eff} at Bryan Texas, taking $g = 9.80\ \text{m}/\text{s}^2$ as exact?

(b) What is the angle between true vertical and the direction of $\vec{g}_{\text{eff}}$ at Bryan Texas?

Problem E.11



The above graphics represent a glass of water sliding down an incline. View the glass as an accelerated frame and answer the following:

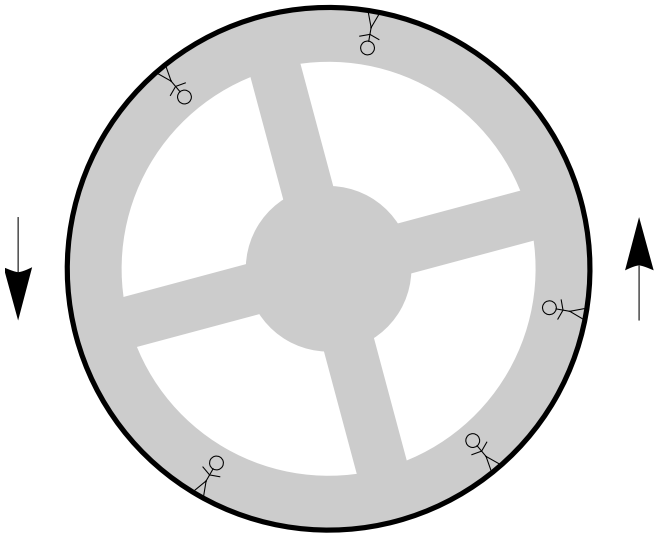
(a) Which describes a glass sliding down a frictionless incline?

(b) Which describes a glass sliding down an incline in the case where the friction is such that the speed of the glass is constant?

(c) Which describes a glass sliding down an incline in the case where there is slight friction, so that the speed of the glass is increasing?

(d) Which describes a glass sliding down an incline in the case where there is high friction, so that the speed of the glass is decreasing?

Problem E.12



The outside rim of a rotating space station has a 150 m radius. It is desired to create an artificial gravity where a 150 lb man has an artificial weight of 50lb. What period of rotation is needed to do this?