Assignment 1, PHYS 2302

assigned Tuesday, September 20; due Thursday, September 29

Problem 1 (FC 1.12)

a) Show that the volume of the parallelepiped whose sides are made up of vectors $\vec{A}$, $\vec{B}$, and $\vec{C}$ (none of which need be perpendicular to each other) is $|\vec{A} \cdot (\vec{B} \times \vec{C})|$.

b) Explain why this proves the "cyclic rule", namely:

$$\vec{A} \cdot (\vec{B} \times \vec{C}) \, = \, \vec{C} \cdot (\vec{A} \times \vec{B}) \, = \, \vec{B} \cdot (\vec{C} \times \vec{A}).$$

Problem 2 (FC 1.22) An ant crawls on the surface of a ball of radius b such that the ant's motion in spherical polar coordinates is given by:

$$r \, = \, b; \qquad \theta \, = \, \frac{\pi}{2} + \frac{\pi}{8} \cos(4\omega t); \qquad \phi \, = \, \omega t, \tag{1}$$

where ω is constant.

a) Find the speed of the ant as a function of time.

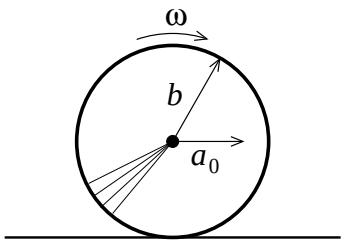
b) Describe the path represented by equations (1). In particular, how many periods of oscillation does the ant undertake per circumnavigation of the sphere?

Problem 3 (FC 1.28) A wheel of radius b rolls along the ground at constant forward acceleration, a_0. As a function of time, find $|\vec{a}\,|$ of any point on the rim of the wheel:

a) relative to the centre of the wheel; and

b) relative to a point on the ground.

c) At a given time, t, which point on the rim of the wheel has the greatest acceleration relative to the ground? Where is this point as $t \to \infty$?



Note: to specify a point along the rim of the wheel, it is sufficient to specify the angular coordinate, θ, counterclockwise from the $+x$-axis (the direction of $\vec{a}_0$ in the figure).

Problem 4 A mass m rests on top of a larger mass, M, which in turn rests on a frictionless surface. When M is prevented from moving, as shown in Fig. 1, F_0 is the maximum horizontal

force that may be applied directly to m before m starts slipping along the top of M.

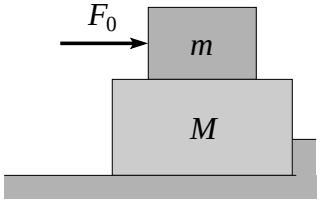


Fig. 1. F_0 applied to m

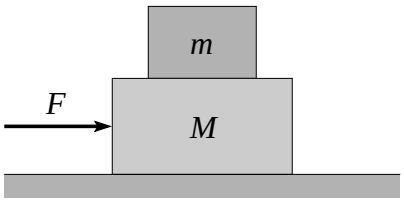


Fig. 2. F applied to M

a) In Fig. 2, the barrier preventing M from moving is removed and a horizontal force F is applied directly to M. In terms of m, M, and F_0, find the maximum value of F, $F_{\max}$, that may be applied without causing m to slip, and the corresponding acceleration of the two masses, a.

b) If $m = 4.00$ kg, $M = 5.00$ kg, and $F_0 = 12.0$ N, find numerical values for $F_{\max}$ and a.

Problem 5 The figure shows a frictionless inclined surface joining a horizontal surface with a kinetic coefficient of friction μ_k between it and the mass m_B. Let the cord attaching m_A and m_B be massless, and let the pulley be massless and frictionless.

a) Find the tension in the cord and the acceleration of the blocks.

b) If $m_A = 4.00$ kg, $m_B = 2.00$ kg, $\theta = 30°$, and $\mu_k = 0.5$, find numerical values for T and a.