2.032 Dynamics Fall 2004

Problem Set No. 6

Out: Wednesday, October 27, 2004
Due: Wednesday, November 3, 2004

Problem 1

Consider the two-dimensional rolling problem discussed in class (disk rolling on a plane, with its main axis of symmetry remaining parallel to the plane).

(a) Show that two of the rolling constraints in this problem cannot be integrated to holonomic constraints.
(b) Show that the above remains true even if we allow for an integrating factor.

Problem 2 (adapted from Baruh, problem 4.3/4)

The radar tracking of a moving vehicle by another moving vehicle is a common problem. Consider the two vehicles A and B in the figure shown below. The orientation of vehicle A must always be toward vehicle B. Express the constraint relation between the velocities and distance between the two vehicles and determine whether this is a holonomic constraint or not.

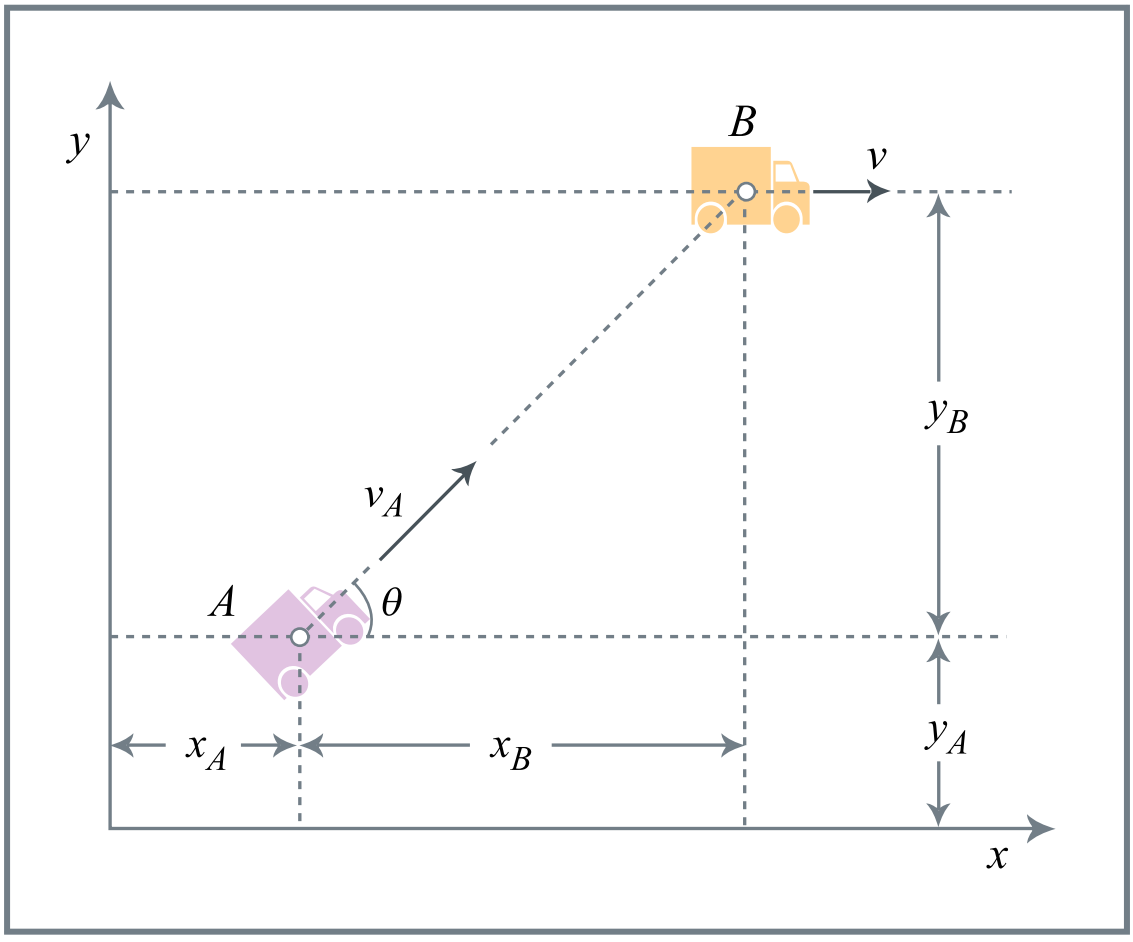

Figure by OCW. After 4.3/4 in Baruh, H. *Analytical Dynamics*. Boston MA: McGraw-Hill, 1999.

Problem 3 (adapted from Baruh, problem 4.4/7)

Find the virtual displacement of point P in the figure shown below. The mass is suspended from an arm which is attached to a rotating column. The pendulum swings in the plane generated by the column and arm.

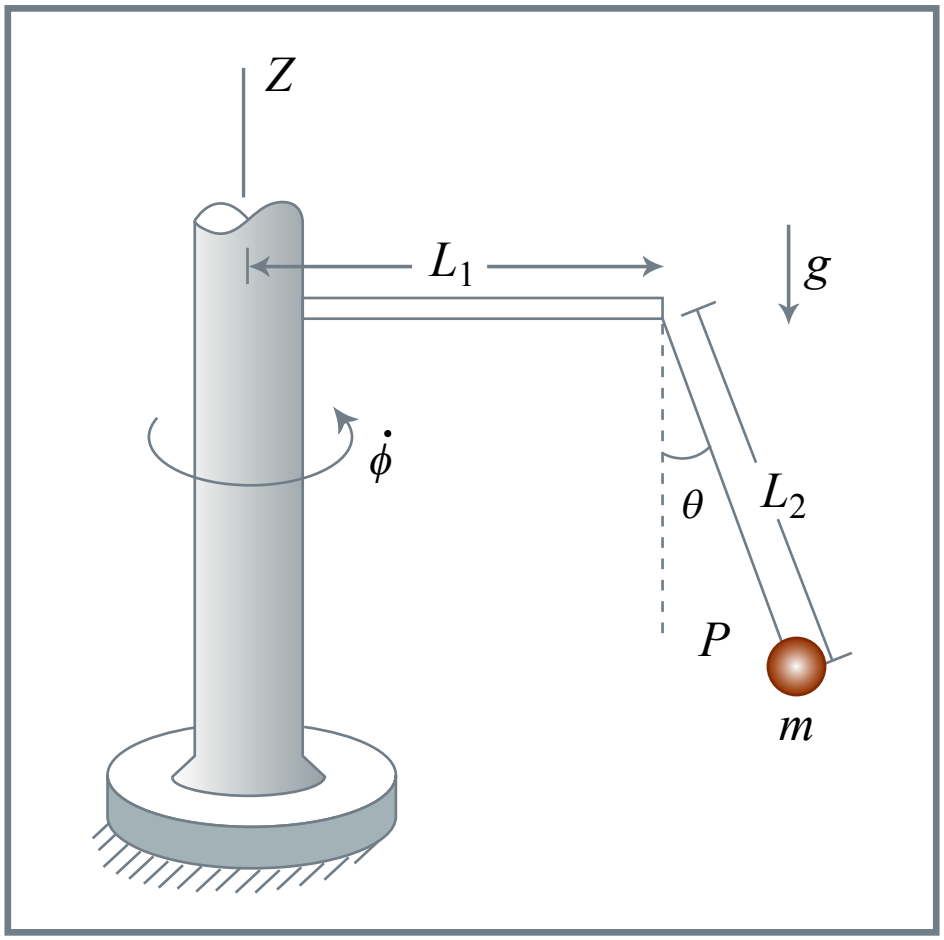

Figure by OCW. After 4.4/7 in Baruh, H. *Analytical Dynamics*. Boston MA: McGraw-Hill, 1999.

Problem 4 (adapted from Ginsberg, problem 6.8)

The figure shows a child's tricycle as viewed from above. When the wheels do not slip over the ground, the velocity of each wheel's center must be perpendicular to the wheel's shaft in the horizontal plane, as shown. Consider a set of generalized coordinates consisting of the position coordinates X_A and Y_A of the steering joint, the angle of orientation θ of the frame, the steering angle β, and the spin angles ϕ_1, ϕ_2, ϕ_3 of the wheels. Derive the velocity constraints among these seven generalized coordinates. From that result, determine the number of degrees of freedom.

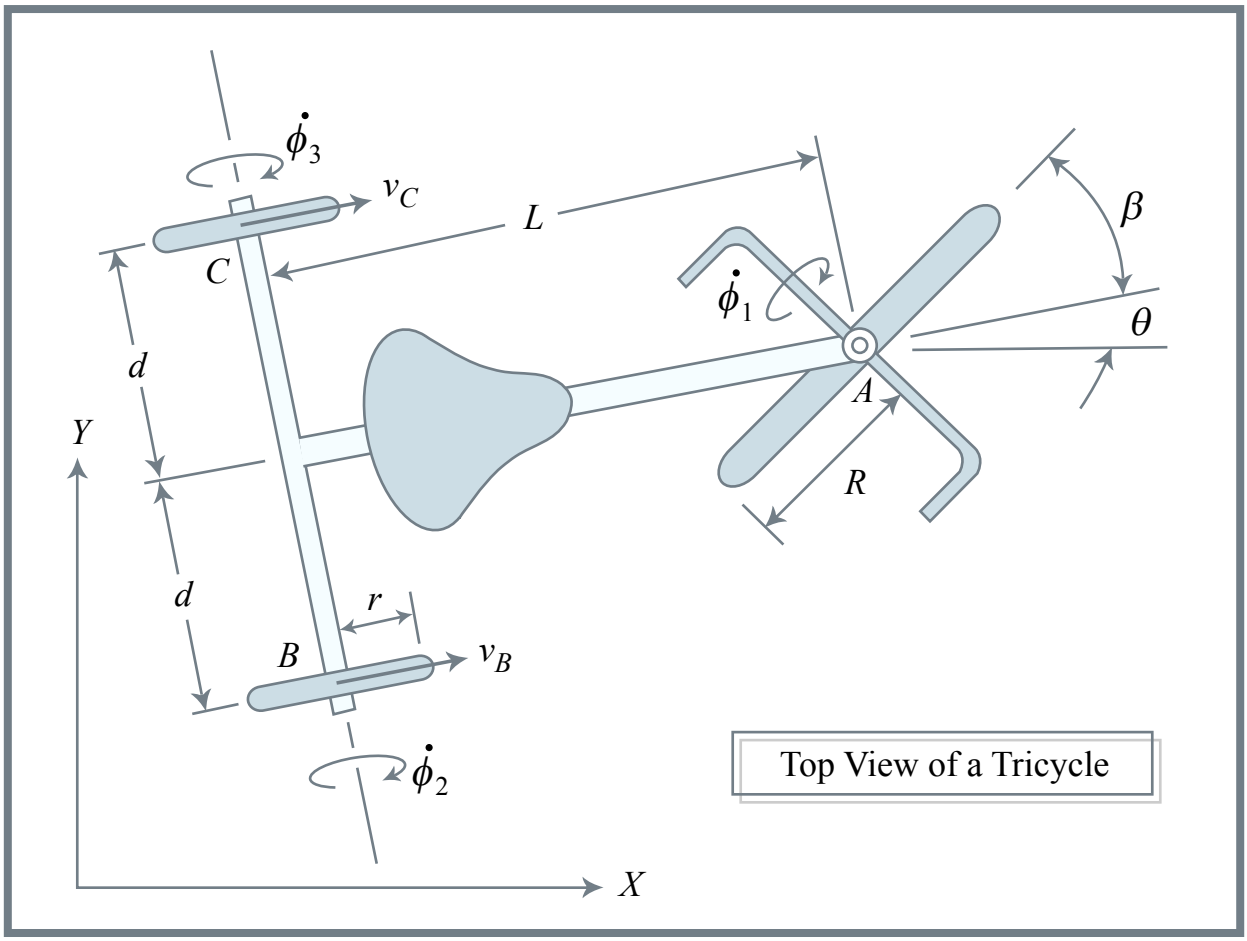

Figure by OCW. After 6.8 in Ginsberg, J. H. *Advanced Engineering Dynamics.* 2nd ed. New York: Cambridge University Press, 1998.