Ph.D. Qualifying Examination

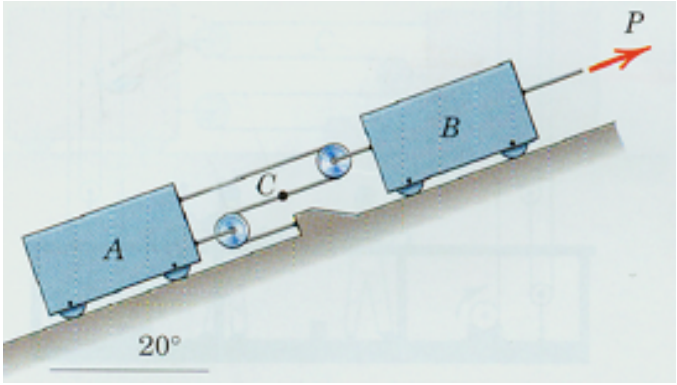
Dynamics

Fall 2009

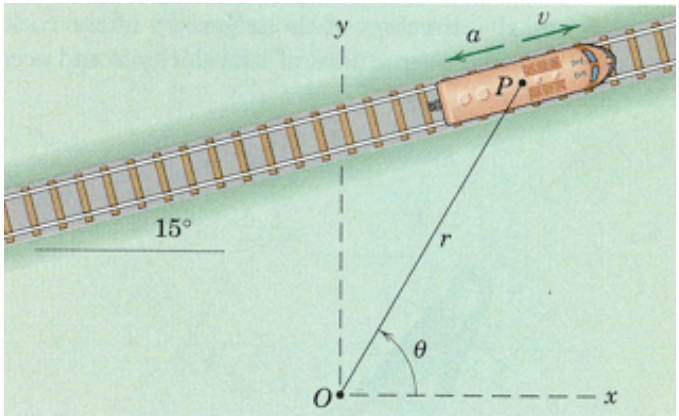
Notes:

- Duration: 2.5 hours.
- Closed book, closed notes (one sheet of formulæ is allowed).
- State your assumptions, methods, and procedures. Show your work on these exam sheets. Add additional sheets, if needed.
- Laptops and cell phones are not allowed.
- Problems are equally weighted.

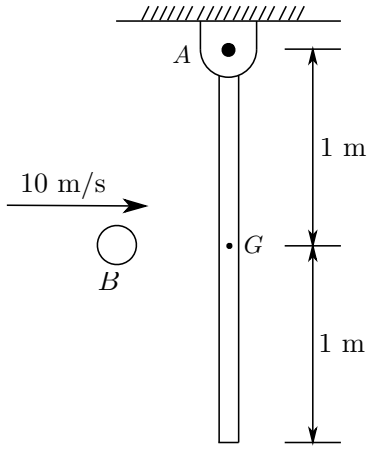
Problem 1. (25) Under the action of force P, the constant acceleration of block B is 6 ft/sec^2 up the incline. For the instant when the velocity of B is 3 ft/sec up the incline, determine the velocity of B relative to A, and the acceleration of B relative to A.



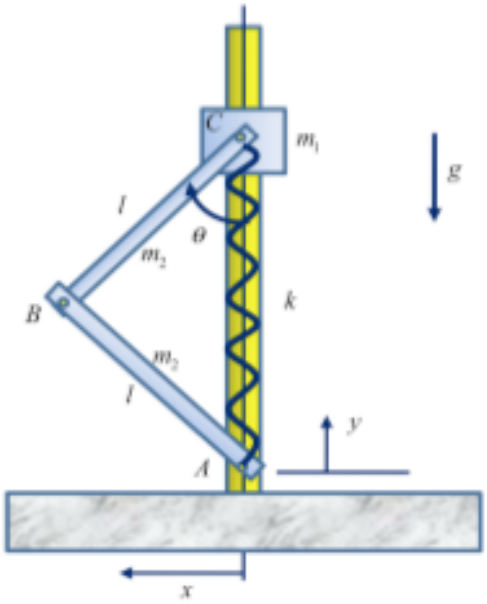
Problem 2. (25) A locomotive is traveling on the straight and level track with a speed $v = 90$ km/h and a deceleration $a = 0.5$ m/s^2 as shown. Relative to the fixed observer at O, determine the quantities $\dot{r}$, $\ddot{r}$, $\dot{\theta}$, and $\ddot{\theta}$ at the instant when $\theta = 60^\circ$ and $r = 400$ m.



Problem 3. (25) The 5-kg slender rod is suspended from the pin at A. If a 1-kg ball B is thrown at the rod and strikes its center with a horizontal velocity of 10 m/s, determine the angular velocity of the rod just after impact. The coefficient of restitution is $\epsilon = 0.4$.



Problem 4. (25) The system shown consists of a mass m_1, which is restricted to sliding vertically on a road AC. A linkage consisting of two homogeneous slender bars of mass m_2 and length l connect m_1 to the fixed point A. The initial position of the mass m_1 is at $\theta = \pi/2$, *i.e.* the mass is at point A. The spring's unstretched length is l and spring constant is k. Assume the spring is linear throughout the range of motion. *NOTE:* The mass moment of inertia of a homogeneous slender bar about its center of mass is $ml^2/12$.



(a) Using the principle of work and energy determine the velocity, v, of mass m_1 at $\theta = \pi/4$ in terms of the given system parameters. To simplify, let $m_1 = m_2 = m$.

(b) How large does k have to be to make this happen?

(c) What are the characteristics of a problem that is best solved by work and energy methods?

(d) What are the advantages of work and energy methods?