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 $v = 90 \text{ km/h}$ and a deceleration $a = 0.5 \text{ m/s}^2$ 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 $r = 400 \text{ m}$. 
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. \textit{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?