1. Please explain or answer the following questions as detailed as possible.
   (3 point each, total 30 points)

   a. What are the differences between trusses, frames, and machines?

   b. What is the coefficient of restitution e? can e exceed one?

   c. What are zero force members?

   d. What is the physical meaning of the radius of gyration of a rigid body?

   e. What is the definition of the instantaneous center of a rigid body during motion?

   f. What are conservative forces?

   g. What is the Coriolis acceleration? What is its physical meaning?

   h. What is the physical meaning of the principle of virtual work?

   i. What is the relationship between bending moment and shear force acted on a structure?

   j. What is the definition of the principal moment of inertia of a rigid body?

2. **Statics (20 points)**

   As shown in Figure 2, please find:

   a. The reaction forces at supports.   (6 points)

   b. Construct the shear force diagram.   What are the maximum shear force and its location? (7 points)

   c. Construct the bending moment diagram.   What are the maximum bending moment and its location? (7 points)
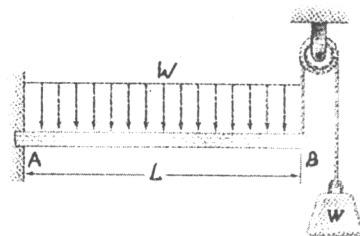

Figure 2

3. **Dynamics of a particle (25 points)**

   A mass M slides without friction on the roller coaster track shown in Figure 3. The curved sections of the track have radius of curvature R. The mass begins its descent from the height h.   At some value of h, the mass will begin to lose contact with the track.   At what θ the mass M will lose contact with the track? Please also calculate the minimum value of h for which this happens. The point A represented an inflection point.

   a. Please tell us how to solve this problem without performing any detailed calculation. (10 points)

   b. Please perform the formulation and calculation to find the final answers (I.e., find θ and h). (15 points)
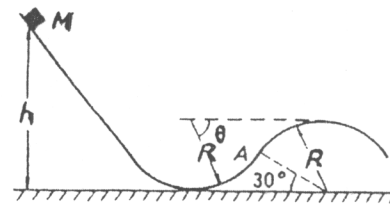

Figure 3

（背面仍有題目,請繼續作答）

4. **Vibration (25 points)**

A mass M is supported by a cantilever beam with negligible mass shown in Figure 4. The formula for deflection is $\delta = \dfrac{L^3 P}{3EI}$. Where P is the force acted on M, EI is the bending stiffness. Neglect gravity effect. Please answer the following questions.

  a. This system can be modeled as a spring-mass system. What is the equivalent spring constant of this system? (5 points)
  b. What is the natural frequency ω_n of this system? (5 points)
  c. If the clamped edge moves upward with an acceleration of 7g (1g = 9.8 m/s^2), what is the deflection δ of the system? (5 point)
  d. If the clamped edge moves up and down by $y = y_0 \sin \omega t$. What is the motion of the mass M? Please discuss the result qualitatively. (Hint: you may like to discuss the result case by case. I.e., $\omega \ll \omega_n$; $\omega \sim \omega_n$; and $\omega \gg \omega_n$) (10 points)
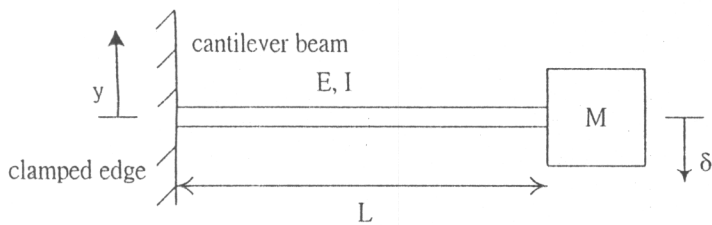

Figure 4