1. (a) Give a brief and precise explanation to the following terms or phrases. (9%)
   (i) free-body diagram
   (ii) degrees of freedom
   (iii) equilibrium.

   (b) Give appropriate answer to the following questions. (6%)
   (i) A particle moves along a helical curve in space, how many degrees of freedom does it have?
   (ii) A particle moves around on a spherical surface in space, how many degrees of freedom does it have?
   (iii) A pitcher in a baseball game pitches a down-curved ball, how many degrees of freedom does the ball have?

   (c) According to the definition given in part (a), explain further the following phrases. (6%)
   (i) stable equilibrium
   (ii) static equilibrium
   (iii) dynamic equilibrium.

   (d) A ball rolls freely on a horizontal plane, what type of equilibrium is it in? Justify your answer with appropriate statements. (4%)
2. (a) 如圖二所示，重量為 W 之均勻細棒 AB 上之點 C 由重量可以忽略之細繩繫上，固定於平滑之鉛直壁上之點 D。棒的一端 A 與鉛直壁接觸並保持平衡的狀態。假設 AB = 2a, AC = b, CD = ℓ, 請問此時棒 AB 與鉛直壁之夾角 α 是多少？（註：G 為棒 AB 之重心）(13 %)

(b) 一位重量為 w 的人站在重量為 W 的小船上，小船停在靜止的水面上。距離小船 ℓ 之處立有一竹竿，現假設船上的人朝竹竿於船上走動 s 的距離時，人與竹竿的距離是多少？（假設船與水面之間無摩擦力）(12 %)
3. The frame shown consists of two members $ABC$ and $DEF$ connected by the links $AE$ and $BF$. Determine the reactions at $C$ and $D$ and the force in links $AE$ and $BF$. (25%)

![Figure 3](image)

4. A bead of mass $m$ is free to slide in the gravity field on a circular hoop of radius $c$ rotating about a vertical axis at a constant angular velocity $\omega_0$ as shown in Fig.4. Determine (1) the acceleration of the bead, (2) the inertia force, (3) all positions $\theta$ at which the bead is in equilibrium, and (4) the holonomic constraint. (25%)

![Figure 4](image)

Figure 4. Equilibrium position of bead on rotating hoop