1. (15%) Design a method to weigh a body part, one lower limb, with the board and scale apparatus.

2. (15%) An 890 N man is standing on one foot as shown in Figure 1. The direction of the resultant of the hip abductor muscle group acting at the greater trochanter makes an angle of 71° with the horizontal. Find the force (Jx and Jy) on the head of the supporting femur.

3. (20%) When the position of a particle P moving in a plane is defined by its polar coordinates r and θ, it is convenient to use radial and transverse components directed, respectively, along the position vector $\mathbf{r}$ of the particle and in the direction obtained by rotating $\mathbf{r}$ through 90° counterclockwise. Assume P has unit vectors $\mathbf{e}_r$ and $\mathbf{e}_n$ in the radial and transverse directions, respectively. Derive the velocity and acceleration of the particle in terms of radial and transverse components.

4. (20%) Find the velocity and acceleration of point A as shown in Figure 2; ω_1=constant, ω_2=constant.

5. (15%) Consider the motion of gyroscopes. The Eulerian angles ϕ, θ, and ψ are used to define the position of a gyroscope (Figure 3). A rotating system of axes $Oxyz$ is attached to the inner gimbal, with the y axis along BB' and the z axis along CC'. Derive the angular velocity ω of the gyroscope in terms of these derivatives, $\dot{\phi}, \dot{\theta}$, and $\dot{\psi}$, by using (a) a rotating system of axes $Oxyz$ and (b) a fixed frame of reference $OXYZ$.

6. (15%) Explain i) Principle of impulse and momentum; ii) Principle of work and energy.

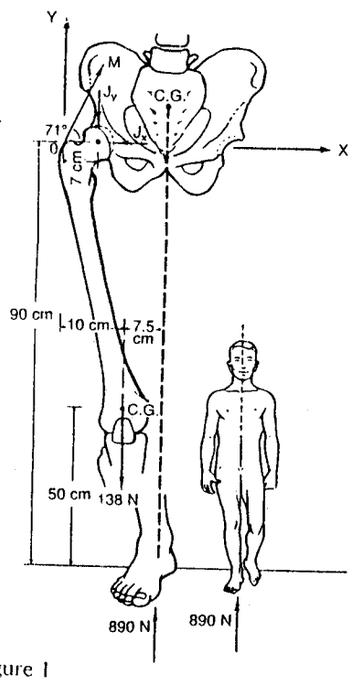

Figure 1

Determination of the compression force on the supporting femoral head in unilateral weight-bearing.

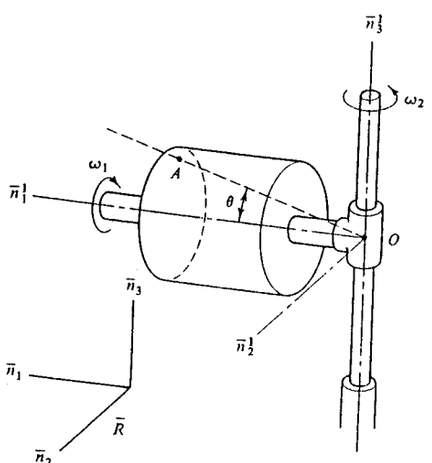

Figure 2

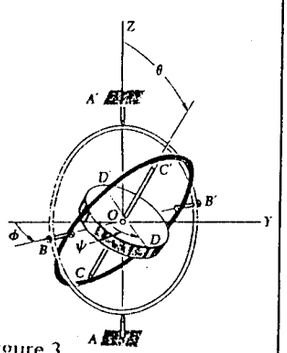

Figure 3