BME 2nd YEAR 2nd SEMESTER SUPPLEMENTARY EXAMINATION
DYNAMICS OF RIGID BODIES

Time – 3 hrs **Marks 100**

Answer any 5 questions
All question carry 20 marks
Symbols have their usual meaning
Vectors are represented in bold

1) Define $\boldsymbol{H_a}$ - the absolute angular momentum for a system of particles.
Starting from the definition, for a system of particles, prove that,

$$\boldsymbol{M} = \frac{d\boldsymbol{H_a}}{dt} + \dot{\boldsymbol{R}} \times M\boldsymbol{V_{C\,abs}}$$

Under what conditions does the 2nd term become zero?

2) Prove, from fundamental principles, that for any vector **A** –

$$\left(\frac{d\boldsymbol{A}}{dt}\right)_{XYZ} = \left(\frac{d\boldsymbol{A}}{dt}\right)_{xyz} + \boldsymbol{\omega} \times \boldsymbol{A}$$

where the frame xyz undergoes general rigid body motion with respect to inertial frame XYZ.

Use the equation to prove that

$$\boldsymbol{V_{XYZ}} = \boldsymbol{V_{xyz}} + \dot{R} + \boldsymbol{\omega} \times \boldsymbol{\rho}$$

Explain the physical significance of the terms.

3) Refer Fig 1. The end A of the uniform slender bar (AB) of length *l* has a constant downward velocity of 2 m/s. For the position when $\theta = 45^o$, find the acceleration of end B, the centre of mass G and the angular acceleration of the of the bar. Preferably use absolute motion method.
Briefly discuss how the problem may be solved by relative motion method.

4) Starting from the definition of $\boldsymbol{H_r}$ for a system of particles, prove that for a rigid body in space motion

[Turn over

$$\{\boldsymbol{H_r}\} = [I]\{\boldsymbol{\omega}\}$$

Define Principal inertia.

Discuss the structure of inertia matrix for a thin rigid body.

5) Refer Fig 1. The uniform slender bar of length *l* and mass *m* is released from rest in the position shown. The friction along the vertical and horizontal surfaces are negligible. Find the initial angular acceleration of the bar. Also find the reactions at A and B.

6) Prove Euler's equation for 3d motion of a rigid body. List all the assumptions and preconditions for the equation to hold.
Draw neat diagram to show Euler's angles.

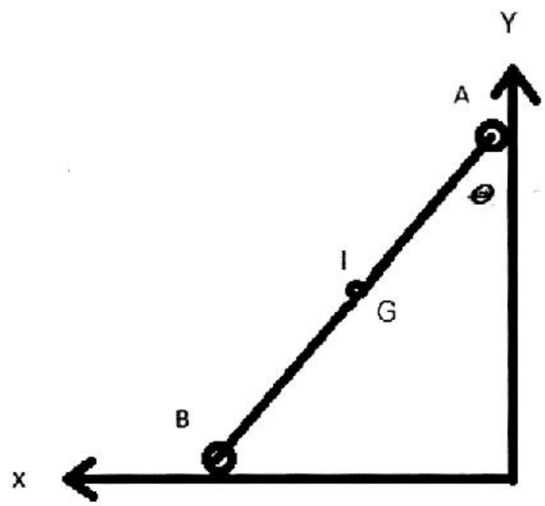

Figure 1