QA INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Date ....FN / AN   Time : 2 Hrs.   Full Marks : 30   No. of Students : 110

Autumn mid – Semester   Deptt. : Mechanical Engineering

Sub. No. : ME 30003 / ME 40601 4^{th} Yr. B. Tech (H)

Sub. Name : Systems and Control

Instructions : Answer all questions. Questions carry equal marks.

Q1. An anti-pitch suspension system is created by mounting a heavy rigid body as sprung mass both in the front and rear suspensions of an automobile as shown in *Fig. 1*. Create a so called bicycle model of the system to simulate its dynamics in one plane as shown in the figure.

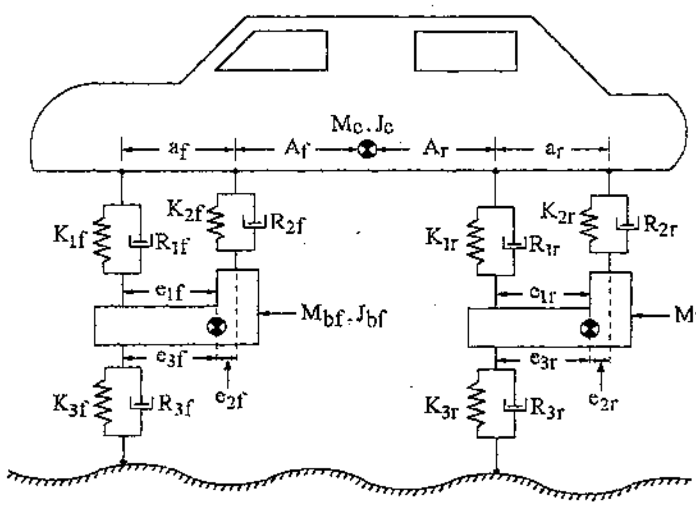

Fig. 1

Q2. A simple model of a gyrocompass is shown in *Fig. 2*. Derive the equations of motion of the system through its bond graph model.

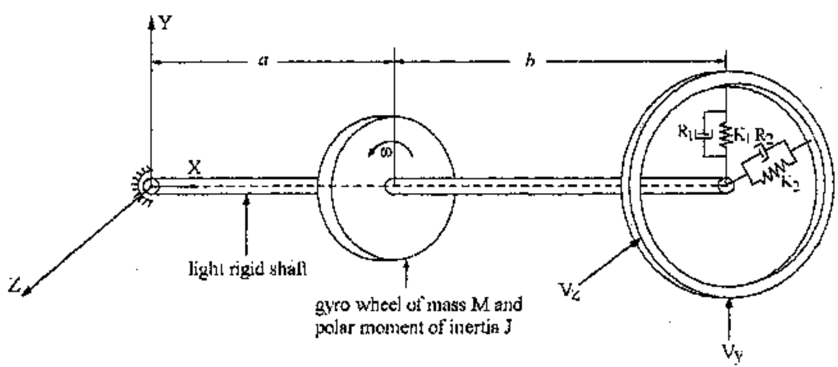

Fig. 2

Reduce the bond model in such a way that it does not contain any gyrator element.

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Q3. **Show the following equivalences and obtain the equivalent parameters.**

a) A capacitor and a gyrator attached to a through junction are equivalent to an inertial element.
b) An inertial element and a gyrator attached to a through junction are equivalent to a capacitive element.
c) A resistive element and a gyrator attached to a through junction are equivalent to a resistive element.
d) All possible pairs of two port elements and through junction combinations are equivalent to one of the two port elements.

Q4. A D.C. motor driving a rigid rotor with a disk is shown in *Fig. 3*. The motor field is separately energised redenring a motor characteristics as $\tau = \mu * i_a$, where i_a is armature current and μ is a constant.

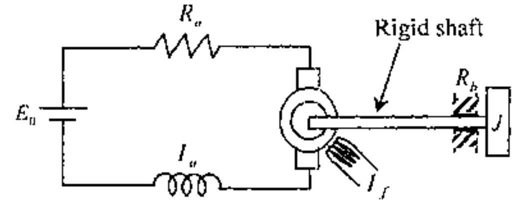

Fig.3

Using gyrator equivalence relations create a gyrator free model of the system referred to electrical side and show that final steady state current in the armature circuit would be $i_a = E_0 * R_b /(\mu^2 + R_a * R_b)$, R_b is equivalent viscous resistance of the bearing. Explain why does armature current, i_a becomes zero if $R_b = 0.0$?

Q5. Draw bond graph model for the system shown in *Fig. 4*. Reduce the graph such that there is no junction loop or differential causality. Augment the graph and derive equation of motion, for small oscillation.

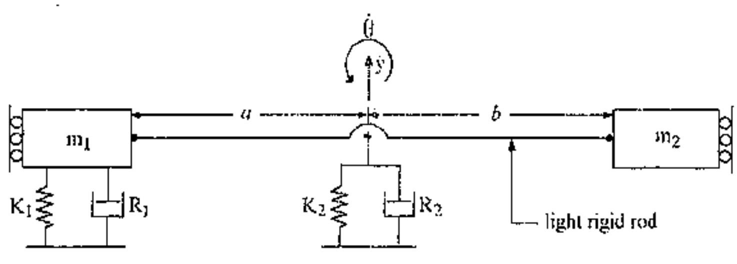

Fig. 4