The University of Melbourne

Semester 2 Assessment, 2008

Department:	MECHANICAL AND MANUFACTURING ENGINEERING
Subject Numbers:	436-354
Subject Title:	MECHANICS 3
Writing time:	3 hours
Reading Time:	15 minutes

This paper has sixteen (16) pages; including a nine page appendix of formulae for section A.

Authorised Materials:
- Standard electronic calculators may be used
- Electronic calculator memory must be erased

Instruction to Invigilators:
- Candidates will be issued with **two** 14-page script-books, initially

Instruction to Students:
- This paper consists of two sections
- You are required to answer **two** questions from each section (i.e. section **A** and section **B**)
- Answers for different sections **must** be completed in separate script-books

This paper may be reproduced and lodged with the Baillieu Library.

This paper can be taken by students at the end of the exam.

SECTION B – DYNAMICS OF MECHANICAL SYSTEMS

Answer only TWO questions in Section B. Each question carries equal weight.

Question B1

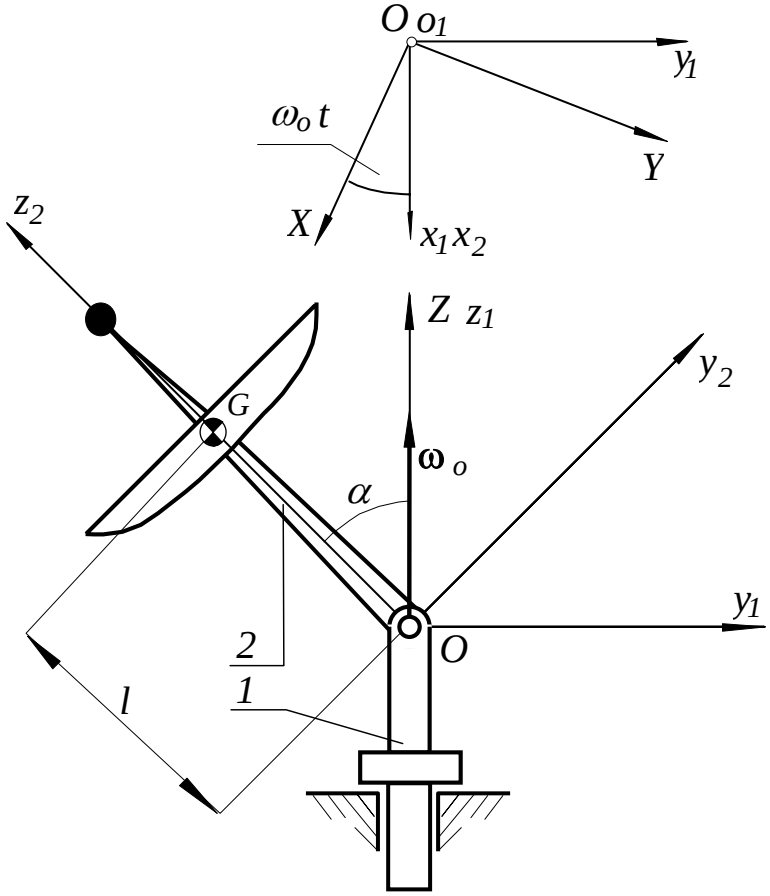

Fig. B1

The column *1* of the radar antenna shown in Fig B1 rotates with the constant angular velocity ω_o about the vertical axis *Z* of the inertial system of coordinates *XYZ*. The system of coordinates $x_1y_1z_1$ is fixed to the column. Its moment of inertia about the axis of rotation z_1 is I_{z1}. The arm *2* is hinged to the column *1* at the point *O*. Its relative position is defined by the following function of time

$$\alpha = A\sin ft$$

Mass of the arm *2* is m_2 and its principal moments of inertia about axis $x_2y_2z_2$ are $I_{x2}=I_{y2}=I_2$, I_{z2} respectively. The distance *l* locates the position of the centre of gravity of the arm *2*.
Produce the expressions for

1. the components of the interaction force at the hinge *O*
2. the components of the interaction moment at the hinge *O*
3. the driving moments that must be applied to the arm *2* and the column *1* to maintain the assumed motion of the system

Question B2

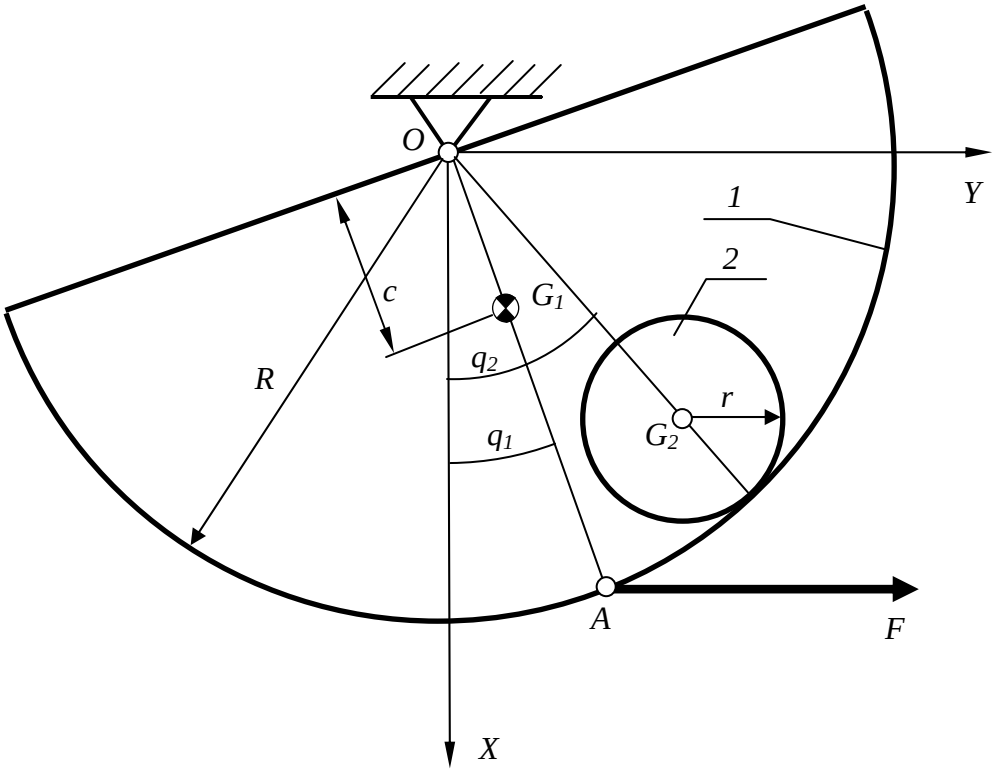

Fig. B2

The semi cylindrical shell *1* is free to rotate about the horizontal axis *Z* of the inertial system of coordinates *XYZ*. Its mass is *M* and its mass moment of inertia about the axis *Z* is I_1. The distance *c* locates its centre of gravity G_1. The instantaneous position of the shell is defined by the independent generalised coordinate q_1. The cylinder *2* can roll over the cylindrical shell without slipping. Mass of the cylinder is *m* and the mass moment of inertia about its axis of symmetry is I_2. The instantaneous position of the cylinder is defined by the independent generalised coordinate q_2. There is a constant and horizontal force *F* applied to the shell at the point *A*.

Produce:

1. the expression for the kinetic energy function of the system
2. the expression for the potential energy function of the system
3. the expression for the virtual work produced by the force *F*
4. the equation of motion of the system (take advantage of the Lagrange's equations)
5. the generalised coordinates corresponding to the equilibrium position of the system

Question B3

1) Prove that the centre of percussion of the pendulum shown in Fig. B3-1 is given by the following formula

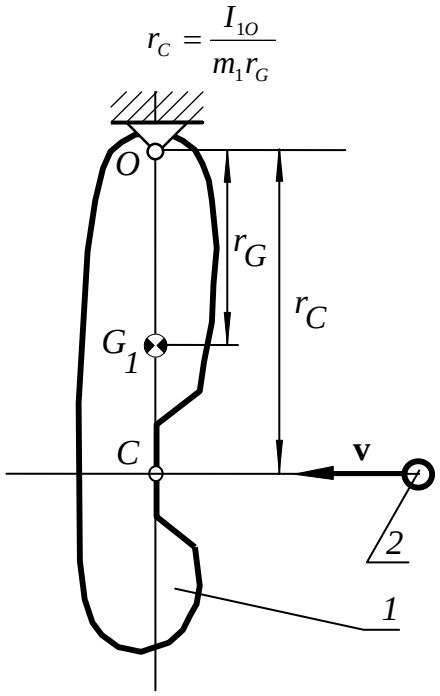

Fig. B3-1

2) Prove that the virtual work produced by the gravity forces acting on a rigid body is

$$\delta W = \mathbf{G} \cdot \delta \mathbf{r}_G$$

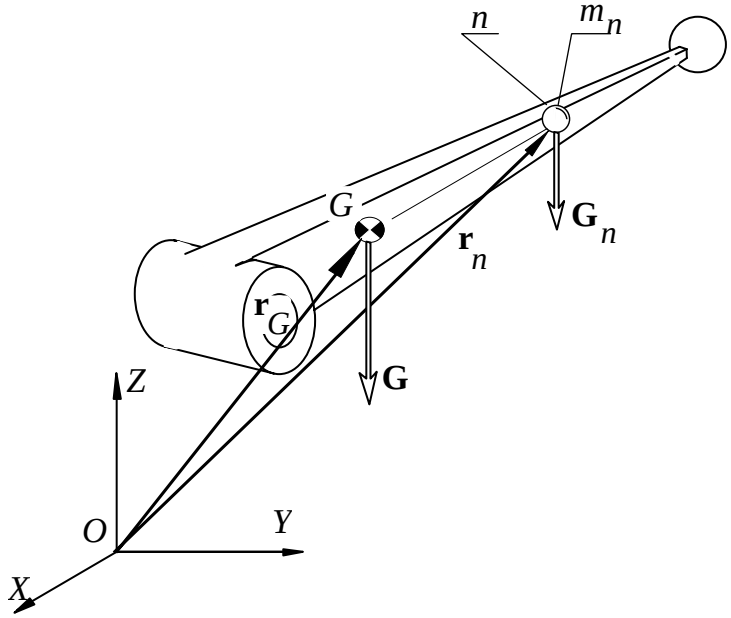

Fig.B3-2

END OF EXAMINATION PAPER