PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY
DEPARTMENT OF MECHANICAL ENGINERING

EXAMINATION QUESTION PAPERS

ME 321
VIBRATION ANALYSIS

SEMESTER TWO – 2022

THE PAPUA NEW GUINEA
UNIVERSITY OF
TECHNOLOGY

Papua New Guinea University of Technology
Department of Mechanical Engineering
Vibration Analysis ME 321
Semester 2 Examination Questions

TIME ALLOWED: 2 HOURS

INFORMATI ON FOR CANDIDATES

1. You have 10 minutes to read the paper. You must not begin writing during this time.

2. **Answer ALL four questions**

3. Please show every step of your work

3. Use only blue or black
ink. Do not use pencil for writing except for drawings and sketches.

4.Start each question on a new page and show all your calculations in the answer book provided. No other written material will be accepted.

5. **Write your NAME and NUMBER clearly** on the front page. Do it now.

6. Calculators are permitted in the examination room. Notes and textbooks are not allowed.

MARKING SCHEME:
Marking scheme for each question is shown.

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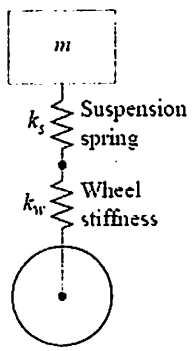
Question 1(20 Marks)

A simplified SDOF model of a vehicle suspension system is shown in Figure below. The mass of the vehicle is 500 kg. The suspension spring has a stiffness of 100,000 N/m. The wheel is modeled as a spring placed in series with the suspension spring. When the vehicle is empty, its static deflection is measured as 5 cm.

(a) Determine the equivalent stiffness of the wheel

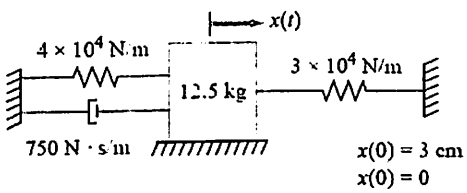
(b) Determine the equivalent stiffness of the spring combination



Question 2(20 Marks)

For the system shown in the figure below

a) Determine the damping ratio
b) State whether the system is underdamped, critically damped or overdamped
c) Determine $x(t)$ *or* $\theta(t)$ for the given initial conditions.

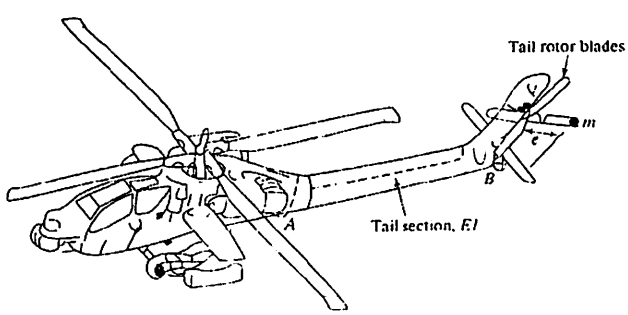


Question 3(20 Marks)

One of the tail rotor blades of a helicopter has an unbalanced mass of $m = 0.5\ kg$ at a distance of $e = 0.15\ m$ from the axis of rotation, as shown in the figure below. The tail section has a length of 4 m, a mass of 240 kg, a flexural stiffness EI of 2.5 $MN.m^2$, and a damping ratio of 0.15. The mass of the tail rotor blades, including their drive system, is 20 kg.

a) Draw a free body diagram of the system when modelled as a cantilever beam.
b) Determine the stiffness, the equivalent mass and the natural frequency of the system.
c) Determine the forced response of the tail section when the blades rotate at 1500 rpm assuming the tail section of the helicopter is described by the following relation

$$x_p(t) = X\sin(\omega t - \phi)$$



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Question 4(20 Marks)

A MEMS system is undergoing simple harmonic motion according to

$$x(t) = [3.1 \sin (2 \times 10^5 t + 0.48) + 4.8 \cos (2 \times 10^5 t - 1.74)] \ \mu\text{m}$$

(a) What is the period of motion?
(b) What is the frequency of motion in Hz?
(c) What is the amplitude of motion?
(d) What is the phase and does it lead or lag?