



DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

University Examination 2021/2022

**FIRST YEAR SECOND SEMESTER EXAMINATION FOR THE DEGREE OF
BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING,
BACHELOR OF EDUCATION TECHNOLOGY IN ELECTRICAL AND
ELECTRONICS ENGINEERING AND BACHELOR OF SCIENCE IN
TELECOMMUNICATION AND INFORMATION ENGINEERING
EME 1202: FUNDAMENTALS OF MECHANICAL ENGINEERING**

DATE: MAY 2022

TIME: 2 HOURS

INSTRUCTIONS

- (a) This paper contains **FIVE** (5) questions.
- (b) You are required to answer **THREE** (3) questions only.
- (c) Question **ONE** is compulsory.
- (d) Attempt any other **TWO** questions.

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Define the following terms

- i. Force (1 mark)
- ii. Compressor (1 mark)
- iii. Gear module (1 mark)
- iv. Dynamics (1 mark)
- v. Pump (1 mark)

b) The angular position of a point on the rim of a rotating wheel is given by $\theta = 4.0t - 3.0t^2 + t^3$, where θ is in radians if t is given in seconds.

- i. What are the angular velocities at $t = 2.0s$ and $t = 4.0s$? (3 marks)
- ii. What is the average angular acceleration for the time interval that begins at $t = 2.0s$ and ends at $t = 4.0s$? (3 marks)

- iii. What are the instantaneous angular accelerations at the beginning and end of this time interval? **(3 marks)**
- c) A 2.00-kg block is placed on a frictionless surface. A spring with a force constant of $k = 32.00 \text{ N/m}$ is attached to the block, and the opposite end of the spring is attached to the wall. The spring can be compressed or extended. The equilibrium position is marked as $x = 0.00 \text{ m}$. Work is done on the block, pulling it out to $x = +0.02 \text{ m}$. The block is released from rest and oscillates between $x = +0.02 \text{ m}$ and $x = -0.02 \text{ m}$. The period of the motion is 1.57 s. Determine the equations of motion. **(6 marks)**
- d) A pinion gear with 22 teeth and a module of 6 mm has a rotational speed of 1200 rpm and drives a gear at 660 rpm. Determine:
- The number of teeth on the driven gear **(3 marks)**
 - The theoretical centre distance **(3 marks)**
- e) With the help of diagrams, explain the difference between concentrated loads and distributed loads (4 marks)

QUESTION TWO

The I35 Bridge in Minneapolis collapsed in summer 2007. On the day of the bridge failure, construction crews occupied the westbound lanes (right side of Fig. Q2). Let F be the forces acting on the truss members by the regular traffic and $2F$ be the force acting on the truss by the heavier construction equipment. Taking into account the average mass of a car to be 1362 kg, it can be estimated that F is 13.35 kN.

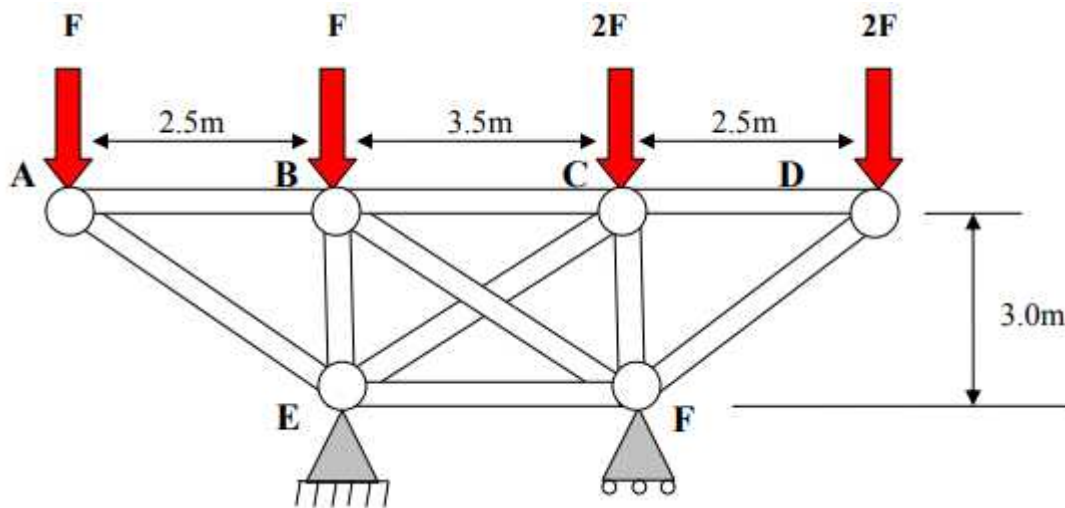


Fig Q2

- a) Determine the reaction forces at supports E and F. Show any free-body diagrams used in your calculations. **(5 marks)**
- b) Determine the forces in members AB and AE. Draw all the free-body diagrams you use in your calculations and show whether the forces on the members you calculate are in tension or compression. **(5 marks)**
- c) The diagonal members BF and EC are called counters, thin cables that are designed to be loaded only in tension. It is known that the support pins at E and F will fail if any of the counters is under a tensile force greater than 10 kN. From the loading on the truss described above, determine the forces on each of the members BF and EC and state which, if any, of the pins will fail. Show all the free-body diagrams associated with your calculations. **(7 marks)**
- d) With the help of examples, differentiate between kinetics and kinematics. **(3 marks)**

QUESTION THREE

Obtain the frequency equation for the system shown in Figure Q 3. Also determine the natural frequencies and mode shapes when $k_1 = 2k$, $k_2 = k$, $m_1 = m$ and $m_2 = 2m$. **(20 marks)**

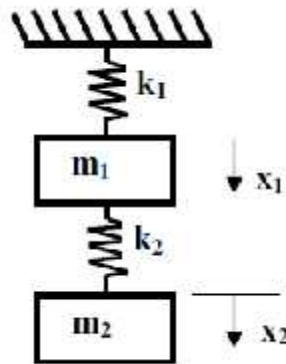


Fig Q3

QUESTION FOUR

- a) A pair of gears has been designed with a velocity ratio of 3.20. The pinion has 20 teeth and the circular pitch is 78.54 mm. Determine:
- The number of teeth on the driven gear. **(2 marks)**
 - The module for the gears. **(4 marks)**
 - The theoretical centre distance. **(4 marks)**

b) Two flat belt pulleys having a center to center distance of 137 cm have drive diameters of 72 cm and 36 cm.

(i) Determine the length of the belt if both pulleys will rotate both directions. **(3 marks)**

(ii) Determine the angle of contact on the small and big pulley. **(4 marks)**

(ii) Find the arc of contact on the small pulley. **(3 marks)**

QUESTION FIVE

a) Define the following terms.

i. Shear stress **(1 mark)**

ii. Shear strain **(1 mark)**

b) The area of the upper surface of a rectangular block is 0.5 m by 0.5m and the lower face is fixed. The height of the block is 1 cm. A shearing force applied to the top face produces a displacement of 0.015mm. Find:

i. The strain **(2 marks)**

ii. The stress **(2 marks)**

iii. The shearing force. **(2 marks)**

Take the modulus of rigidity to be $4.5 \times 10^{10} \text{ N/m}^2$

c) A pipe 1 m diameter and 15 km long transmits water of velocity of 1 m/sec. The friction coefficient of pipe is 0.005. Calculate the head loss due to friction. (3 marks)

d) The pipe of a syphon has 75 mm diameter and discharges water to the atmosphere, as shown in figure Q5. Neglect all possible losses.

i. Determine the velocity of flow. **(3 marks)**

ii. Find the discharge. **(3 marks)**

iii. What is the absolute pressure at the point **(3 marks)**

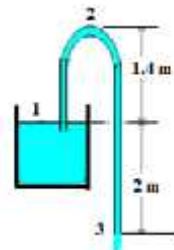


Fig Q5