



**FACULTY OF ENGINEERING AND THE ENVIRONMENT**

**DEPARTMENT OF MINING ENGINEERING**

**ENGINEERING MECHANICS**

**EMN 1103 / EMG 1103**

**Final Examination Paper**

**November/December 2024**

This examination paper consists of 5 printed pages

**Time Allowed: 3 hours**

**Total Marks: 100**

**Examiner's Name: Mr. K. Garapo**

**INSTRUCTIONS**

1. Answer all questions in Section A and any three questions from Section B.
2. Begin each solution for a new question on a new page and show all working.
3. Section A consists of **four** questions carrying **10 marks** each.
4. Section B consists of **four** questions carrying **20 marks** each.
5. Use of calculators is permissible.

**Additional Requirements**

None

**MARK ALLOCATION**

<b>Questions</b>	<b>Marks</b>
<b>Question 1</b>	<b>10</b>
<b>Question 2</b>	<b>10</b>
<b>Question 3</b>	<b>10</b>
<b>Question 4</b>	<b>10</b>
<b>Question 5</b>	<b>20</b>
<b>Question 6</b>	<b>20</b>
<b>Question 7</b>	<b>20</b>
<b>Question 8</b>	<b>20</b>
<b>Total Attainable</b>	<b>100</b>

## SECTION A (40 Marks): Answer all questions

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### Question 1

- a) Define the term vector. [4]
- b) Given a force  $\vec{F} = 30\hat{i} - 90\hat{j} + 60\hat{k}$  N, determine the following:
- i) The vector components of  $\vec{F}$ . [3]
- ii) The scalar components of  $\vec{F}$ . [3]

### Question 2

- a) Describe a gear drive. [4]
- b) State one advantage of a gear drive. [3]
- c) State one disadvantage of a gear drive. [3]

### Question 3

- i) State the four basic quantities encountered in mechanics. [4]
- ii) State Newton's third law of motion. [3]
- iii) Explain Newton's third law of motion. [3]

### Question 4

Draw diagrams to illustrate the following structures:

- a) Simple truss. [4]
- b) Cantilever beam. [3]
- e) Simply-supported beam. [3]

## SECTION B (60 Marks): Answer any three questions

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### Question 5

Refer to Figure B1 to answer the following questions, given that all six acute angles are  $45^\circ$  (implying that triangles ABC, BCD and CDE are right angled):

- a) Draw a free-body diagram for the truss shown in Figure B1. [5]
- b) Determine the reactions at B and E. [6]
- c) Use the method of sections to determine the force in member BC. [9]

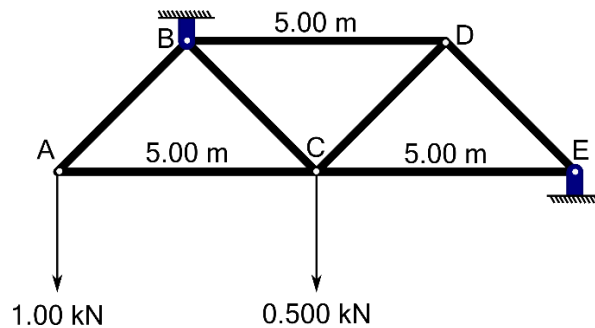


Figure B1. A loaded truss which is supported at B and E.

### Question 6

Refer to Figure B2, which shows three forces acting on an eye bolt, to answer the following questions:

- a) Using an appropriate diagram, outline Varignon's principle. [5]
- b) Determine the displacement  $\vec{r}$  of the centre of the bolt eye from point A. [3]
- c) Determine the resultant  $\vec{R}$  of the three forces acting on the bolt eye. [8]
- c) Determine the magnitude  $M$  of the moment  $\vec{M}$ , about point A, of the three forces acting on the bolt eye. [4]

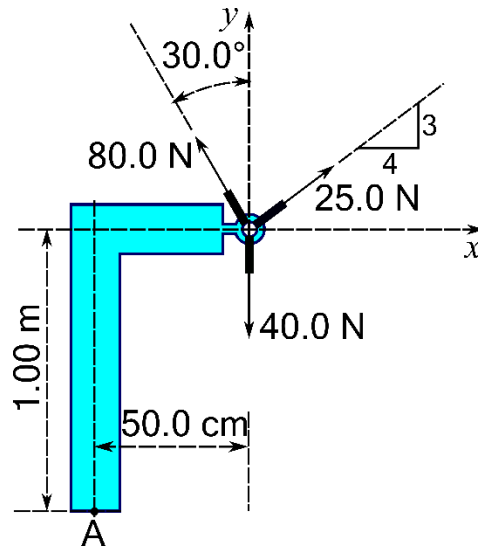


Figure B2. Three forces acting on an eye bolt.

### Question 7

a) Given the displacement  $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ , from O, of a force  $\vec{F} = f_x\hat{i} + f_y\hat{j} + f_z\hat{k}$  acting on a rigid body show that the moment of the force about O is given by

$$\vec{M} = \vec{r} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ x & y & z \\ f_x & f_y & f_z \end{vmatrix}.$$

[12]

b) Determine the moment  $\vec{M}$ , about a point O, of the force  $\vec{F} = 4.00\text{N}\hat{i} - 3.00\text{N}\hat{j}$  applied at a displacement  $\vec{r} = 0.50\text{m}\hat{i} + 1.25\text{m}\hat{j}$  from O. [6]

c) Is the moment you calculated in b) clockwise or counterclockwise about the z-axis, on the x-y plane? [2]

### Question 8

a) Define a simple machine. [4]

b) State two examples of simple machines. [4]

c) Refer to the diagram shown in Figure B3 to answer the following questions:

i) Determine the mechanical advantage of the pulley system. [4]

ii) Determine the magnitude of the tension  $T$ . [4]

- iii) Given that the 20 kg mass is hoisted 50 cm, determine the work done by the tension  $T$ . [4]

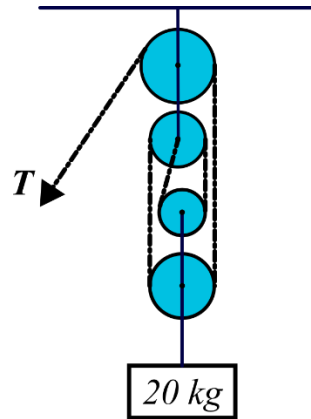


Figure B3. An ideal pulley system used to hoist a 20 kg mass.