



# UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA

FIRST SEMESTER EXAMINATIONS, NOV. – DEC. 2018

COURSE NO: MC/EL/RN/CE/GL/GM/MN/MR/PE/ES167

COURSE NAME: BASIC MECHANICS

CLASS: BSc I

TIME: 3 HOURS

Name: \_\_\_\_\_ Index Number: \_\_\_\_\_

## SECTION A

### ATTEMPT ALL QUESTIONS

Answers for the multiple choice questions, should be indicated on both answer booklet and question paper. The question paper must be tied loosely into the answer booklet. Rough work should be done in the question paper. Use a value of  $g = 9.81 \text{ m/s}^2$  for all acceleration due to gravity on earth.

The stock mounted on the lathe is subjected to a force of 60N as shown in Figure 1. Use the Figure 1 to answer questions 1 and 2.

1. Determine the coordinate direction angle  $\beta$ .

- a.  $60^\circ$
- b.  $75^\circ$
- c.  $120^\circ$
- d.  $150^\circ$

2. Express the force as a Cartesian vector.

- a.  $\{30i + 15.5j + 42.4k\} \text{ N}$
- b.  $\{30i - 30j + 42.4k\} \text{ N}$
- c.  $\{30i - 52j + 42.4k\} \text{ N}$
- d.  $\{30i + 30j + 42.4k\} \text{ N}$

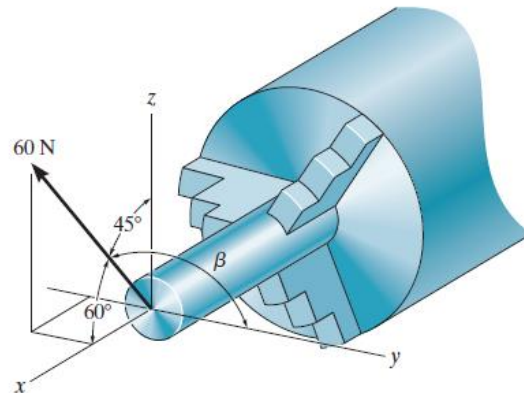


Figure 1

3. A bus travelling along a straight road with constant acceleration passes station A with a velocity of  $18 \text{ ms}^{-1}$  and goes on to pass station B with a velocity of  $10 \text{ ms}^{-1}$ . The bus finally comes to a stop at station C. If the distance between stations A and B is 800 m, what is the distance between stations B and C?

- a. 290.5 m
- b. 488.6 m
- c. 226.5 m
- d. 357.1 m

4. What time does the bus take to travel from station A to station C?

- a. 98.2 s
- b. 128.6 s
- c. 56.5 s
- d. 155.9 s

In Figure 2, block A rests on block B and against the vertical wall. Block B rests on the horizontal floor. The weight of A is  $W_A = 981\text{ N}$  and that of B is  $W_B = 7848\text{ N}$ . The coefficient of friction is  $\mu = 0.3$  for all pairs of surfaces in contact and the angle  $\theta$  is  $60^\circ$ . It is required to determine the minimum value of the force P to move block A down.

Complete the free body diagrams shown in Figure 2 and use them to answer Questions 5 – 10.

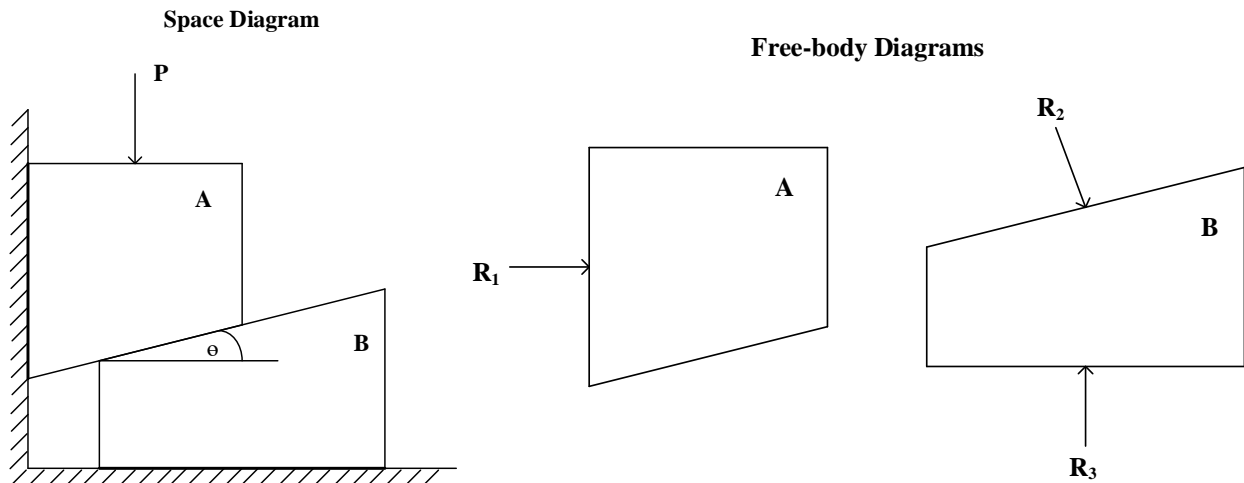


Figure 2

- Which of the following equations describes the **horizontal** equilibrium of **block A**?
  - $R_1 + \mu R_2 \cos \theta = R_2 \sin \theta$
  - $R_1 - \mu R_2 \cos \theta = R_2 \sin \theta$
  - $R_1 + \mu R_2 \sin \theta = R_2 \cos \theta$
  - $R_1 - \mu R_2 \sin \theta = R_2 \cos \theta$
- Which of the following equations describes the **vertical** equilibrium of **block A**?
  - $P + W_A = R_2 \cos \theta - \mu R_2 \sin \theta - \mu R_1$
  - $P + W_A = R_2 \cos \theta + \mu R_2 \sin \theta + \mu R_1$
  - $P + W_A = R_2 \cos \theta - \mu R_2 \sin \theta + \mu R_1$
  - $P + W_A = R_2 \cos \theta + \mu R_2 \sin \theta - \mu R_1$
- Which of the following equations describes the **horizontal** equilibrium of **block B**?
  - $R_2 \sin \theta = \mu R_3 - \mu R_2 \cos \theta$
  - $R_2 \cos \theta = \mu R_3 + \mu R_2 \sin \theta$
  - $R_2 \cos \theta = \mu R_3 - \mu R_2 \sin \theta$
  - $R_2 \sin \theta = \mu R_3 + \mu R_2 \cos \theta$
- Which of the following equations describes the **vertical** equilibrium of **block B**?
  - $R_3 = W_B - R_2 \cos \theta + \mu R_2 \sin \theta$
  - $R_3 = W_B + R_2 \cos \theta + \mu R_2 \sin \theta$
  - $R_3 = W_B - R_2 \cos \theta - \mu R_2 \sin \theta$
  - $R_3 = W_B + R_2 \sin \theta + \mu R_2 \sin \theta$
- What is the magnitude of the reaction  $R_2$ ?
  - 5.2 kN
  - 3.4 kN
  - 4.8 kN
  - 3.8 kN
- A G-clamp is used to hold a block by tightening with torque of 10 Nm. The single square-threaded screw has a mean diameter of 20mm and a pitch of 3 mm. the coefficient of friction is 0.35. Determine the torque required to loosen the clamp.

- a. 7.35 Nm
- b. 8.66 Nm
- c. 4.32 Nm
- d. 5.55 Nm

11. Cords  $AB$  and  $AC$  can each sustain a maximum tension of 800 N as shown in Figure 3. If the drum has a weight of 900 N, determine the smallest angle  $\theta$  at which they can be attached to the drum.

- a.  $55.8^\circ$
- b.  $29.4^\circ$
- c.  $34.2^\circ$
- d.  $62.7^\circ$

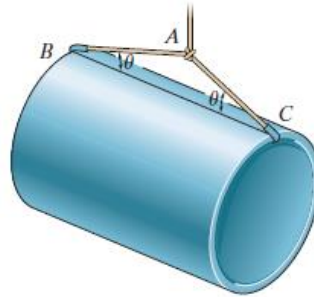


Figure 3

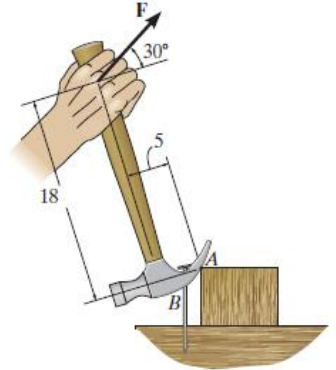


Figure 4

12. The handle of the hammer is subjected to the force of  $F = 20\text{ N}$  as shown in Figure 4. Determine the moment of this force about the point A.

- a. 362 Nm
- b. -362 Nm
- c. 267 Nm
- d. -267 Nm

13. The motion of a particle is defined by the relation  $x = t^4 - 10t^2 + 8t + 12$ , where  $x$  and  $t$  are expressed in meters and seconds, respectively. Determine the acceleration of the particle when  $t = 1\text{ s}$ .

- a.  $8\text{ ms}^{-2}$
- b.  $11\text{ ms}^{-2}$
- c.  $-11\text{ ms}^{-2}$
- d.  $-8\text{ ms}^{-2}$

14. The following are assumptions made in trusses except

- a. members are straight and rigid
- b. force will act at joint only
- c. joint is made up of frictionless pin
- d. None of the above

15. Couple is same about any point in plane.

- a. True
- b. False

16. An 80-kg block rests on a horizontal plane as shown in Figure 5. Find the magnitude of the force  $\mathbf{P}$  required to give the block an acceleration of  $2.5\text{ m/s}^2$  to the right. The coefficient of kinetic friction between the block and the plane is  $\mu_k = 0.2$ .

- a. 535 N
- b. 1092 N
- c. 466 N
- d. 370 N

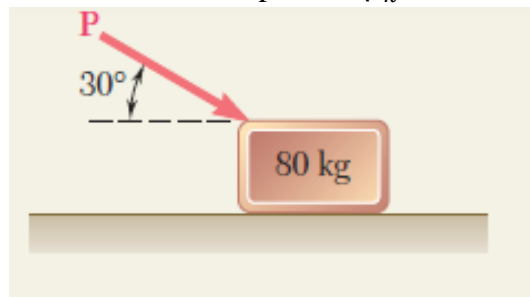


Figure 5

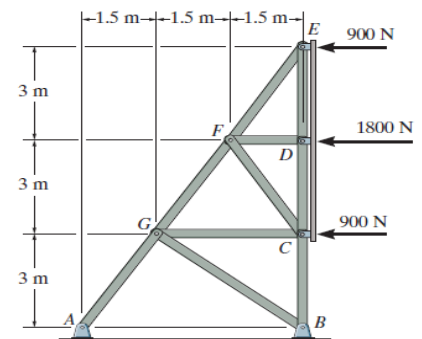


Figure 6

17. Determine the force in member  $FG$  of the truss used to support the sign as shown in Figure 6.

- a.  $-4.02$  kN
- b.  $2.01$  kN
- c.  $4.02$  kN
- d.  $-2.01$  kN

18. A force is characterised by the following

- a. magnitude
- b. direction
- c. point of application
- d. all of the above

19. When forces exist in a single plane, the force system formed is referred to as

- a. concurrent forces
- b. parallel forces
- c. coplanar forces
- d. spatial forces

20. The following are laws of friction except

- a. frictional force is always opposite to direction of motion
- b. frictional force is dependent of area of contact
- c. the ratio of maximum static frictional force and normal reaction  $N$  is constant
- d. the plane of contact is tangent to both bodies at the point of contact

**SECTION B**

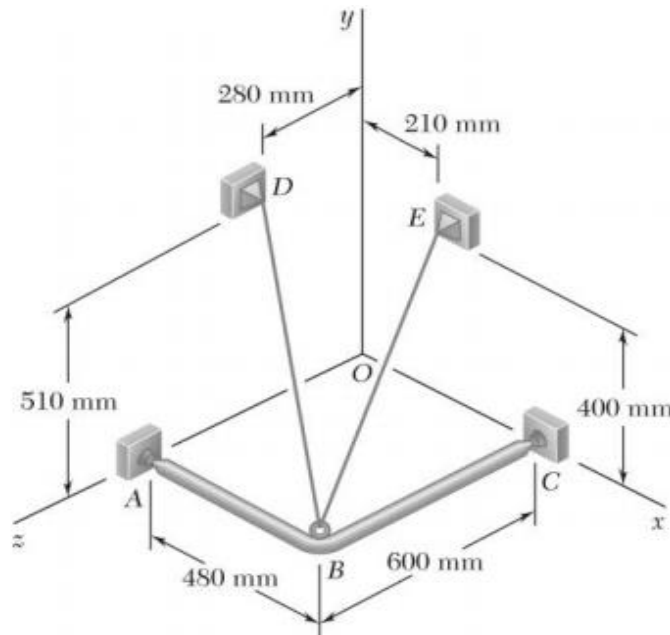
**INSTRUCTIONS**

- Answer **only two** questions in this section.
- Full credits will be given to clear and logical presentation of solution rather than mere writing of final answers. Whenever necessary, draw free body diagrams, state the principle being applied, and/or assumptions made.
- All diagrams are not drawn to scale. Use the given dimensions on each drawing for your calculations whenever necessary.
- Neglect masses and frictional effects, if they are not given.
- Begin each answer on a **FRESH PAGE**.

**Question 1**

**[20 marks]**

- a) A frame ABC is supported in part by cable DBE that passes through a frictionless ring at B as shown in Figure 1. Knowing that the tension in the cable is 400 N, determine
- i) the components of the force exerted by the cable on the support at E
  - ii) its moment about the point C
- [10 marks]**



**Figure 1**

- b) A rod AB hinged at A and attached at B to cable BD supports the loads shown in Figure 2. Knowing that  $d = 200$  mm, determine the:
- i) Tension in cable BD
  - ii) Reaction at A.
- [10 marks]**

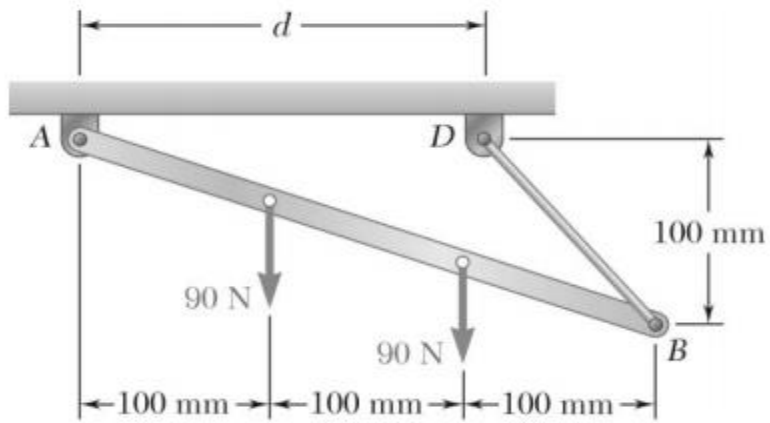


Figure 2

Question 2

[20 marks]

- a) Determine the force in members  $CD$ ,  $CF$ , and  $GF$  as shown in Figure 3 and state if these members are in tension or compression. [14 marks]

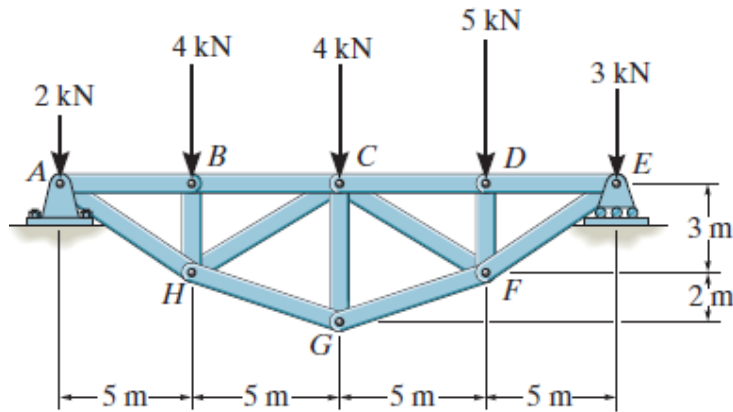
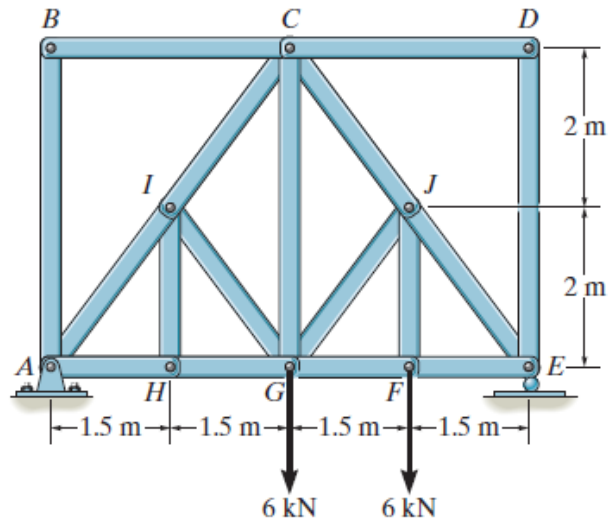


Figure 3

- b) For the given loading, determine the zero-force members in the truss shown in Figure 4. [6 marks]



**Figure 4**

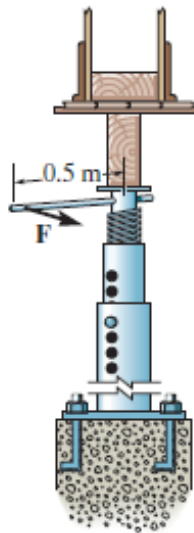
[Caution: wrong listing attracts negative marks]

**Question 3**

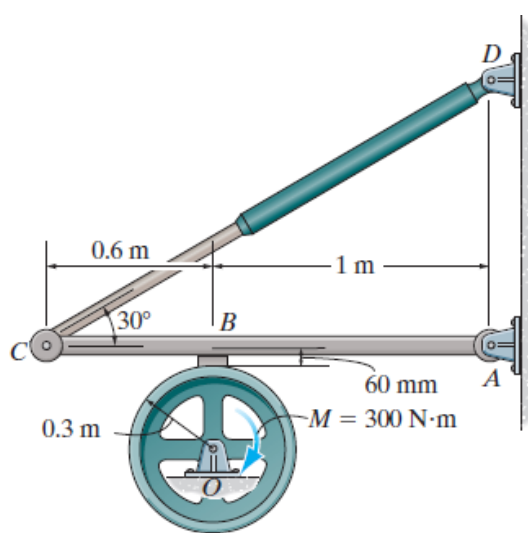
**[20 marks]**

- a) i) The column is used to support the upper floor as shown in Figure 5. If a force  $F = 80 \text{ N}$  is applied perpendicular to the handle to tighten the screw, determine the compressive force in the column. The square-threaded screw on the jack has a coefficient of static friction of  $\mu_s = 0.4$ , mean diameter of 25 mm, and a lead of 3 mm.
- ii) If the force  $F$  is removed from the handle of the jack, determine if the screw is self-locking.

**[10 marks]**



**Figure 5**



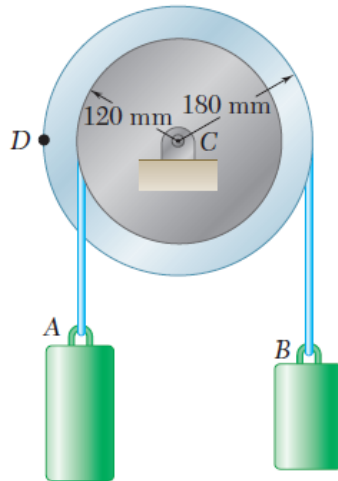
**Figure 6**

- b) If a torque of  $M = 300 \text{ N}\cdot\text{m}$  is applied to the flywheel as shown in Figure 6, determine the force that must be developed in the hydraulic cylinder  $CD$  to prevent the flywheel from rotating. The coefficient of static friction between the friction pad at  $B$  and the flywheel is  $\mu_s = 0.4$ .

**[10 marks]**

**Question 4****[20 marks]**

- a) The motion of a particle is defined by their relation  $x = t^4 - 10t^2 + 8t + 12$ , where  $x$  and  $t$  are expressed in meters and seconds respectively. Determine the position, the velocity, and the acceleration of the particle when  $t = 1$ s. [5 marks]
- b) A pulley and two loads are connected by inextensible cords as shown in Figure 7. Load A has a constant acceleration of  $300 \text{ mm/s}^2$  and an initial velocity of  $240 \text{ mm/s}$ , both directed upward. Determine
- the number of revolutions executed by the pulley in 3 s,
  - the velocity and position of load B after 3 s,
  - the acceleration of point D on the rim of the pulley at  $t = 0$ .

**[15 marks]****Figure 7****Examiners: D. Yellezuome/ I. Osei/ E. Adaze**