MATHEMATICS & MECHANICS 2
7066

CAMEROON GENERAL CERTIFICATE OF EDUCATION BOARD

General Certificate of Education Examination

JUNE 2015 **ADVANCED LEVEL**

Subject Title	**MATHEMATICS & MECHANICS**
Paper N°.	**2 – Applied Mechanics**
Subject Code No	**7066**

THREE HOURS

This paper consist of three sections. Answer ALL questions in Section A and FOUR questions in either Section B or Section C.

Only Candidates of BUILDING CONSTRUCTION should attempt questions in section B, and only candidates of ELECTRICAL TECHNOLOGY should attempt question in Section C.

You are advised to use one hour on Section A.

Calculators are allowed. Where not stated, take g $10m/s^2$.

You are reminded of the necessity for good English and orderly presentation in your answers.

SECTION A
ANSWER ALL QUESTIONS

1. Two points A and B are defined in a reference system $(\vec{o}, \vec{i}, \vec{j}, \vec{k})$ as follows $\overrightarrow{OA}$ (3, 1, 4); $\overrightarrow{OB}$ (8, 3, 2)
   (i) What are the components of vector $\vec{AB}$ (2 marks)
   (ii) Calculate the magnitude of vector $\vec{AB}$ (2 marks)

2. Determine the centrifugal acceleration of a body after 6 complete rotations in 2 seconds. The body rotates with a uniform speed in a circle of radius 1 m. (4 marks)

3. For a mass M = 5 kg rotating with an angular acceleration α = 1 rad/s², and situated at the distance R = 800 mm from the rotation centre. Calculate the moment to which the mass is subjected. (4 marks)

4. An irregular body has mass 12 kg. Its moment of inertia about a given axis passing through its centre of mass is 4 kgm². Determine the moment of inertia about a parallel axis shifted by 0.5 m from the origin. (4 marks)

5. Calculate the vector moment about the point O of the force $\vec{F}$ of 1414N at A as shown in figure 1. (4 marks)

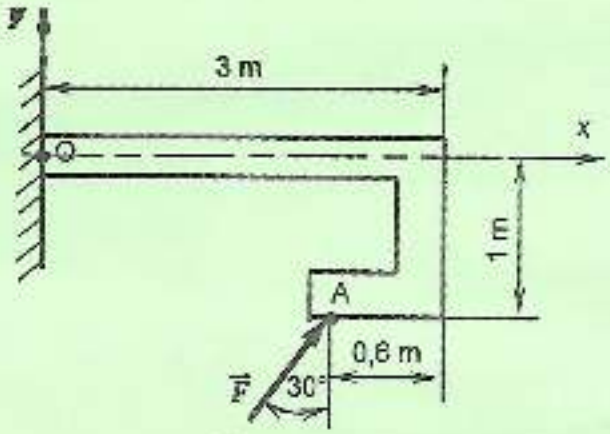

Figure 1

6. A certain machine exerts a force of 200N on a box whose mass is 30kg. The machine moves the box through a distance of 20 meters along a smooth horizontal floor. What amount of work has the machine done on the box? (4 marks)

7. Calculate the x component of the centre of gravity of the surface in figure 2 below. Hint: ½ circle $Y'_G = \frac{4r}{3\pi}$ (4 marks)

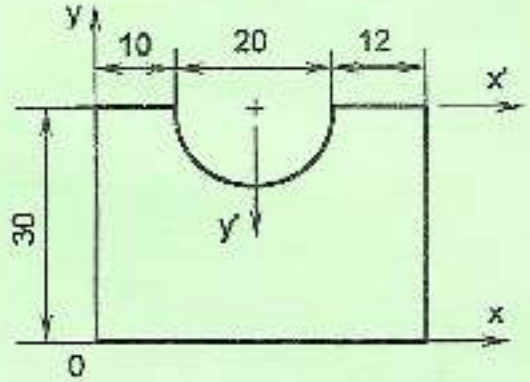

Figure 2

SECTION B: FOR BUILDING CONSTRUCTION CANDIDATES ONLY
ANSWER ANY FOUR QUESTION BELOW

8. After the preliminary studies of one of the pillars of a building structure, the following were obtained:
   - Pillar section: (20x30) cm^2
   - Height of pillar: 3.15m
   - Centralised load supported by the pillar: Nu = 6412.668N.

   Additional Information

▪ $L_f = 0.7l_u$	▪ $\alpha = 0.6(\frac{50}{\lambda})^2$; if $50 < \lambda \leq 100$
▪ $i = \frac{h}{\sqrt{12}}$	▪ $\alpha = \frac{0.85}{1+0.2(\frac{\lambda}{35})^2}$; if $\lambda \leq 50$
▪ $\lambda = \frac{l_f}{i}$	▪ $Nu \leq \alpha\{\frac{Br.fc28}{0.9\gamma b} + \frac{Ast.fe}{\gamma_s}\}$
▪ $fc_{28} = 25mpa$	▪ $A_{min} = Max\{\frac{4U}{100} ; \frac{0.2U}{100}\}$
▪ $\gamma_b = 1.5$	

Use Appendix I for sections of rods

(a) Calculate the cross sectional area of the longitudinal reinforcement necessary for this pillar. **(10 marks)**

(b) State when the expression $A_{min} = Max\{\frac{4U}{100} ; \frac{0.2B}{100}\}$ is used during the structural design of a reinforced concrete pillar. **(3 marks)**

(c) Choose the rods combination and sketch a cross section of this pillar showing their disposition. **(5 marks)**

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9. Figure 3 below represents one of the beams of an overhead transportation system used in a warehouse. The displacement of objects is done through a bloc of trolleys as indicated in figure 3 below.

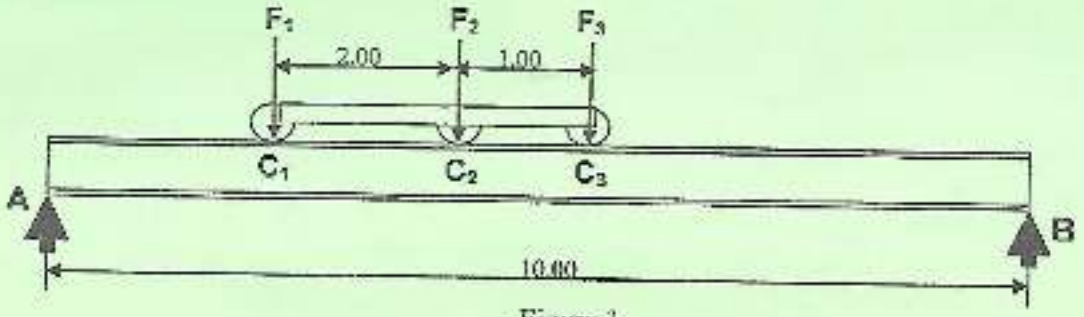

Figure 3

Considering that: $F_1 = 10KN$, $F_2 = 30KN$ and $F_3 = 10KN$,

(a) Determine using Barre's Theorem the maximum bending moment under each wheel or load and indicate the critical position of the trolley (neglect the self weight of the profile). **(15 marks)**

(b) With the trolley in its critical position, determine the contact actions at A and B. **(3 marks)**

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10. (a) A metal tie beam is lap-jointed as shown in figure 4 below. The ties are 10mm thick and 100mm wide. The joint is fastened by 5 bolts of 5mm diameter each as shown.

(i) What is the value of the force in each bolt if it is stressed to 200MPa **(3 marks)**

(ii) Calculate the stress in the metal tie at the joint near the bolt and far away **(4 marks)**

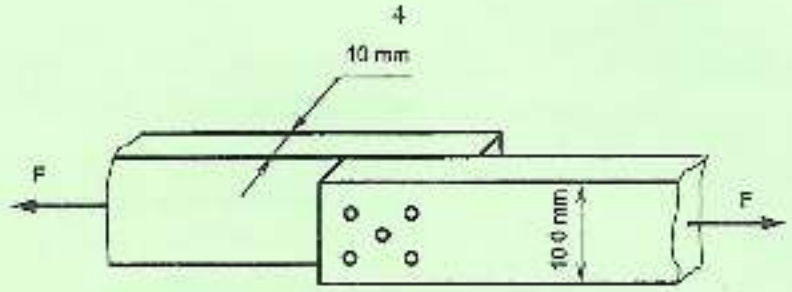

Figure 4

(b) A reinforced concrete foundation is eccentrically loaded by a RC column as shown in figures 4b1 and 4b2 below.

(i) Define the middle third. **(2 marks)**

(ii) Evaluate the ground reaction stresses under the footing along X-X. **(5 marks)**

(iii) Show the ground reaction on the footing graphically. **(2 marks)**

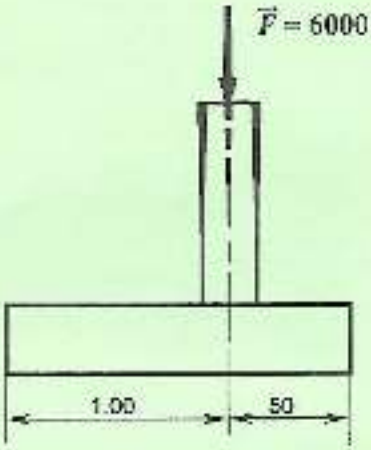

Figure 4b1

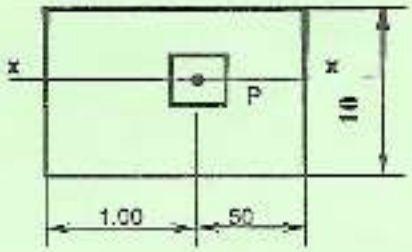

Figure 4b2

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11. A light non-stretchable string passes over a smooth pulley and carries masses of 4kg and 3kg at it ends. Masses are released from rest. Let us take $g = 10m/s^2$ see figure 5

(a) Calculate the acceleration of the mass. **(6 marks)**

(b) Calculate their speed after 5 seconds. **(5 marks)**

(c) Calculate the distance travel in 5 seconds. **(5 marks)**

(d) At that instant, the string suddenly cuts. How much higher does the lighter mass move? **(3 marks)**

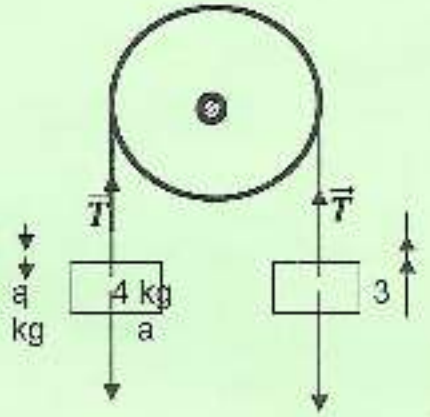

Figure 5: Pulley system

12. Figure 6 below is the mechanical sketch of one of the beams of an upper floor of a public building.

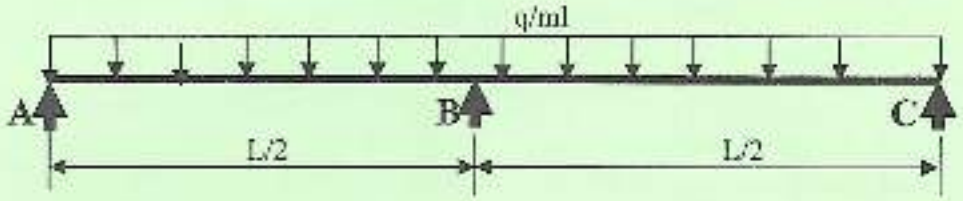

Figure 6

(a) Determine by superposition the three contact actions in function of q and L. **(8 marks)**
(b) Sketch the shearing force and bending moment diagrams in function of q and L. **(6 marks)**
(c) Deduce T_{max} and M_{max} given that q = 200daN and L = 10m **(4 marks)**

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13. (a) An open channel in a V-shaped each side being inclined at 45 degrees to the vertical as shown in figure 7a. If the rate of flow Q is 42.5dm/s when the depth of the water at the centre is 225mm. Calculate the slope of the channel using Chezy's formulae assuming that C is 49 in SI unites. **(9 marks)**

Chezy's formula states that: $V = C\sqrt{(m,)}$

See figures 7a below.

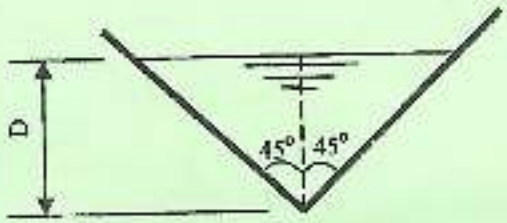

Figure 7a

(b) The section of the Channel is now transformed into a trapezoidal shape with the bottom width B = 3.6m and the side slopes 1 vertical to 1 horizontal as shown in figure 7b. What will be the discharge Q if the depth of water is 1.2m and the slop is 1 in 1600. **(9 marks)**

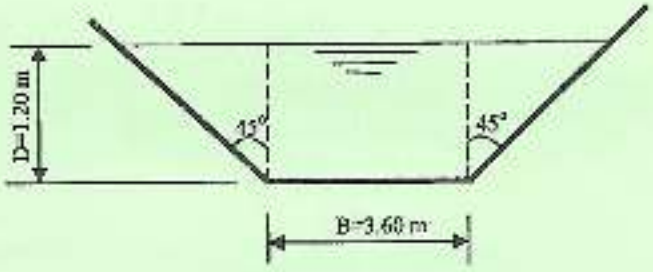

Figure 7b

SECTION C
FOR CANDIDATES OF ELECTRICAL TECHNOLOGY ONLY
ANSWER ANY FOUR QUESTIONS

14. A block placed under the head of the claw hammer 1 as shown in figure 8, greatly facilitates the extraction of the nail **2**. A force of 200N is applied at the point A to pull the nail. The contacting surfaces at C are sufficiently rough to prevent slipping.

(a) Draw the free body diagram of the nail 2. **(4 marks)**

(b) Draw the free body of hammer 1. **(4 marks)**

(c) Calculate the tension of the nail and the force exerted by the hammer head on the block 3 at the point C. **(11 marks)**

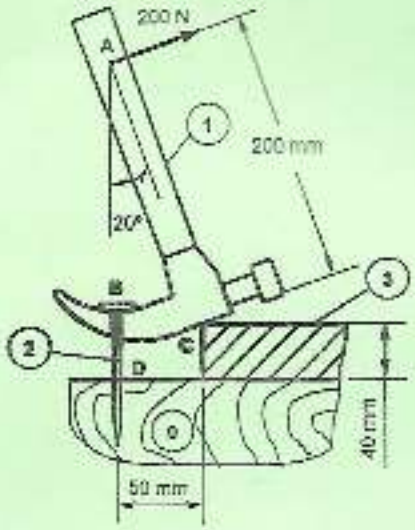

Figure 8

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15. The pendium shown in figure 9 below consists of a slender rod(**1**) and a disk(**2**) with a hole in it. The rod has a density of 7000kg/m^3, an external diameter of Ø500*mm*, internal diameter of Ø250 *mm*, and thickness of 10mm.

(a) Calculate the mass moment of inertia of the pendulum about an axis directly perpendicular to the page and passing through the pin at B: **(11 marks)**

(b) Calculate the mass center G of the pendulum. **(7 marks)**

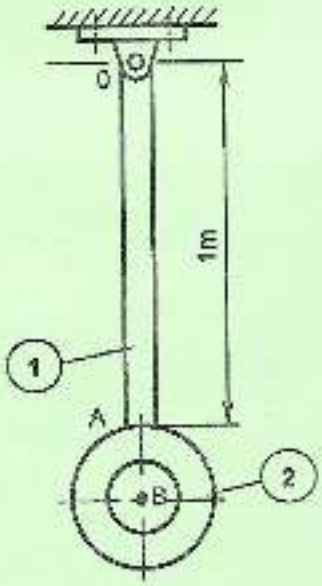

Figure 9

16. A cord is wrapped around a homogeneous disk of radius R=0,5 m and mass m=15kg as shown in figure 10. If the cord is pulled up with a force M of magnitude 180N, determine:
    (a) The acceleration of the center of the disk; **(8 marks)**
    (b) The angular acceleration of the disk; **(6 marks)**
    (c) The acceleration of the cord. **(4 marks)**

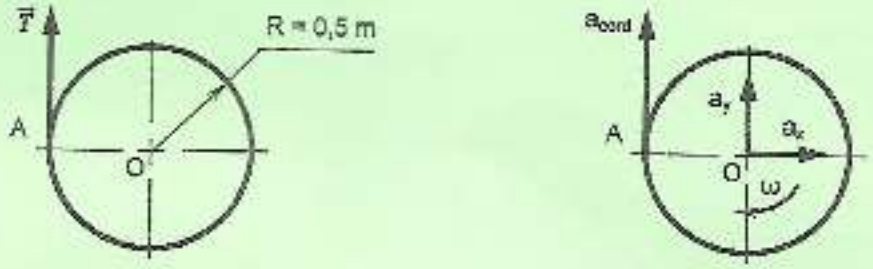

Figure 10

17. In electrical engineering, a hammer or pile driver 1 of 600kg mass is used to plant poles 2 in the soil as shown in figure 11 . The hammer moves from resting position and drop by 2,5m on a pillar of 2000kg mass, then rebounds by r = 0,2m.
    (a) Determine the velocity of the hammer before the impact. **(9 marks)**
    (b) Determine the velocity of the hammer after the impact. **(9 marks)**

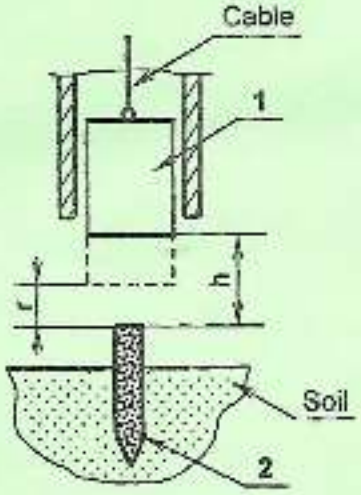

Figure 11

18. An automobile of mass M= 900kg moves along a straight horizontal smooth road with a velocity of 4,4m/s. At a certain moment, the driver decides to accelerate and after a distance OA = 500 m, the velocity becomes 26,40m/s. Assume that the acceleration is constant from O to A. Find:

    (a) The work done by the engine of the automobile from O to A; **(5 marks)**
    (b) The acceleration of the automobile; **(5 marks)**
    (c) The time spent to cover the distance OA; **(4 marks)**
    (d) The power developed by the engine **(4 marks)**

19. In the hoist system shown in figure 12, the electric motor rotates at a revolution speed N= 1440 rev/min. The gear box has a transmission ratio R = 30 and an efficiency under load η=0,82. The winch drum has a pitch diameter D = 200 mm and a maximum load capacity of one (01) ton. Frictional losses in winch drum itself are negligible. If the maximum load is lifted at a constant velocity, determine:

(a) The rotational speed of the winch drum; **(2.5 marks)**
(b) The speed at which the load will be lifted; **(2.5 marks)**
(c) The output torque from the gearbox as well as the output power; **(5 marks)**
(d) The motor torque. **(3 marks)**
(e) The motor power. **(5 marks)**

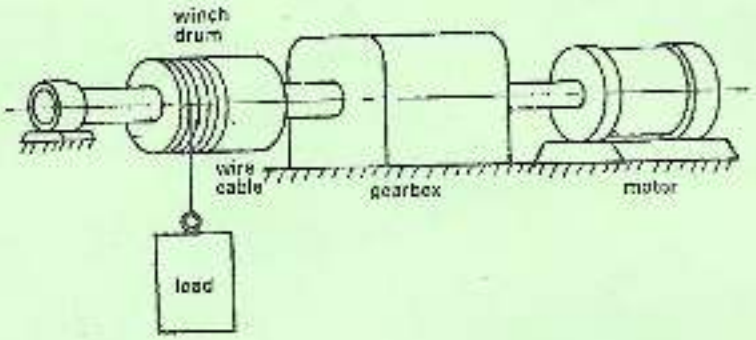

Figure 12

Appendix 1
CROSS SECTIONAL AREA OF STEEL RODS (cm^2)

N°. / O(mm)	1	2	3	4	5	6	7	8	9	10	11	12
5	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4
6	0.3	0.6	0.9	1.1	1.4	1.7	2.0	2.3	2.6	2.8	3.1	3.4
8	0.5	1.0	1.5	2.01	2.51	3.01	3.51	4.02	4.52	5.02	5.52	6.03
10	0.78	1.57	2.35	3.14	3.92	4.71	5.49	6.28	7.06	7.85	8.63	9.42
12	1.13	2.26	3.39	4.52	5.65	6.78	7.91	9.04	10.2	11.3	12.4	13.6
14	1.54	3.08	4.62	6.15	7.69	9.23	10.8	12.3	13.9	15.4	16.9	18.5
16	2.01	4.02	6.03	8.04	10.1	12.3	14.1	16.1	18.1	20.1	22.1	24.1
20	3.14	6.28	9.42	12.6	15.7	18.8	22.0	25.1	28.3	31.4	34.7	37.7
25	4.9	9.81	14.7	19.6	24.5	29.4	34.3	39.2	44.1	49.1	54.0	58.9
32	8.04	16.1	24.1	32.2	40.2	48.2	56.3	64.2	74.2	80.4	88.4	96.5
40	12.6	25.1	37.7	50.2	62.8	75.4	88.0	100	113	126	138	151