2101/303 2105/303
2102/303 2106/303
2103/303 2107/303
2104/303 2108/303
MECHANICAL TECHNOLOGY
Oct./Nov. 2008
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

# DIPLOMA IN MECHANICAL ENGINEERING (PRODUCTION OPTION)
# DIPLOMA IN MECHANICAL ENGINEERING (PLANT OPTION)
# DIPLOMA IN AUTOMOTIVE ENGINEERING
# DIPLOMA IN CONSTRUCTION PLANT ENGINEERING
# DIPLOMA IN AGRICULTURAL ENGINEERING (FARM POWER AND MACHINERY OPTION)
# DIPLOMA IN MECHANICAL ENGINEERING (FABRICATION TECHNOLOGY AND METALLURGY OPTION)
# DIPLOMA IN AERONAUTICAL ENGINEERING
# DIPLOMA IN MECHANICAL ENGINEERING (MATERIALS TECHNOLOGY AND METALLURGY OPTION)

MECHANICAL TECHNOLOGY

**3 hours**

## INSTRUCTIONS TO CANDIDATES

*You should have the following for this examination:*

*Answer booklet;*
*Drawing instruments;*
*Mathematical Tables/non programmable Calculator;*
*Steam tables.*

*This paper consists of **FOUR** sections **A**, **B**, **C** and **D**.*
*Answer **ONE** question from **A**, **B**, **C** and **TWO** questions from **D**.*
*All questions carry equal marks.*
*Maximum marks for each part of a question are shown.*

**This paper consists of 6 printed pages.**

**Candidates should check the question paper to ascertain that all the pages are printed as indicated and no questions are missing.**

## SECTION A

## MECHANICS OF MACHINES

*Answer any **ONE** question from this section.*

1. A thin uniform rod of 1.6 m long and a mass of 12 kg and it stands on a table vertically on one end. It is given a small initial disturbance causing it to fall. Show that if the lower end begins to slip on the table when the rod has fallen through 19.66°, the coefficient of friction between the rod and the table must be equal to 0.27.

   Hint: Solve in terms of forces P and Q and calculate the horizontal and vertical components H and V respectively of the end force, from P and Q.

   $$\mu = \frac{H}{V}$$

   Do not try to prove that $\theta = 19.66°$, but calculate for P and Q for this particular value.

   (20 marks)

2.

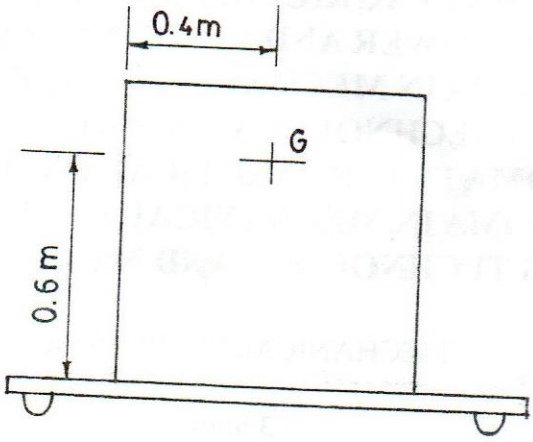


Fig. 1

Figure 1 above shows the rear view of a crate on the flat floor of a truck. The mass centre G is 0.6 m above the floor and 0.4 m from the left hand edge.

(a) Determine the maximum speed at which the truck may travel around a right-hand curve of radius 50 m, banked inwards to an angle of 10° without the crate slipping if the friction coefficient between the truck floor and crate is 0.6.

(10 marks)

(b) If the crate is prevented by a stop from slipping, calculate the maximum truck speed such that the crate does not tip outwards when travelling round the same truck.

(10 marks)

## SECTION B

## STRENGTH OF MATERIALS

*Answer any **ONE** question from this section.*

3. (a) A type of spring consists of n parallel strips of metal of width 6. The spring carries a central vertical load W which is balanced by equal end reactions. Assuming that the centre lines of all the plates are initially circular arcs of the same radius R, that each plate has a uniform thickness t, and overlaps the one below it by an amount

$$a = \frac{L}{2n}$$

at each end and that these overlaps are tapered in width to a triangular shape. Show from first principles that the deflection of the ends of the spring relative to the centre is

$$\frac{3WL^3}{8nEbt^3}$$

(15 marks)

(b) Find the load required to straighten a carriage spring which has 6 strips of breadth 7.5 cm and thickness 1 cm. The top strip have a length of 1 m if the deflection of the top strip when unloaded is 6.0 cm. The overlaps are each equal to half the total length of the bottom strip and their breath is uniformly tapered to a point.

Take E = 200 GN/m$^2$. (2 marks)

(c) Calculate the number of turns required for 0.6 cm deflection in a spring made of steel 2 cm diameter and forming a cylindrical coil 12.5 cm mean diameter. If the load is 500N and G is 80 GN/m$^2$. Assume the spring is close -coiled. (3 marks)

4. (a) Given that a solid circular shaft has a length L and radius r in cross section. T are the applied torques, equal and opposite about a longitudinal axis. Show, stating the assumptions made that when twisting occurs;

$$\frac{T}{J} = \frac{\tau}{r} = \frac{G\theta}{L}$$

(11 marks)

(b) A solid circular shaft of 25 cm diameter is to be replaced by a hollow shaft, the ratio of the external to internal diameters is 2 to 1. Find the diameter of the hollow shaft if the maximum shearing stress is to be the same as for the solid shaft.
What percentage economy in mass will this change effect. (9 marks)

## SECTION C

## FLUID MECHANICS

*Answer **ONE** question from this section.*

5. (a) Define the following terms as used in reciprocating pumps:

(i) Coefficient of discharge

(ii) Slip. (2 marks)

(b) A double acting reciprocating pump has a cylinder of 20 cm diameter, and a stroke of 40 cm. The pump is required to deliver water at a rate of 6,000 litres per min, to a height of 80 m.
If the frictional head losses at the suction and delivery are 2 m and 16 m respectively, and the velocity of water in the pipe is 2 m/sec. Determine:

(i) the speed at which the pump should run in rev per min;

(ii) the power required by the pump when the pump efficiency and slip are 90% and 1.8% respectively. (8 marks)

(c) (i) State **three** main reasons why large air vessels are fitted in reciprocating pumps.

(ii) A double acting reciprocating pump is used to pump water to a height of 30 m above the pump axis. The cylinder diameter (d) and the stroke lengths are 20 cm and 2d respectively. The pump delivers water through a 13 cm diameter pipe and 36 m long, when the pump is running at 40 rev/min.
Determine the pressure in the cylinder at the beginning of the delivery stroke, when an air vessel is fitted 3 m on the deliver side from the cylinder. Take f = 0.008 (10 marks)

6. (a) Show that the loss of head in a pipe due to friction in laminar flow is given by:

$$h_f = \frac{32\mu VL}{wD^2}$$

where: $\mu$ is coefficient of dynamic friction;
V is the fluid velocity;
D is the pipe diameter;
w is the specific weight of the fluid.
State the assumptions made. (15 marks)

(b) A pump is designed to pump fuel in a pipe of 650 mm diameter and 850 m long, at a rate of 200 lit per min.
The oil viscosity is 0.8 Nm/s and the specific gravity is 0.9. If the pipe is inclined upwards at 1 in 80 and assuming laminar flow, determine:

(i) the pressure difference required at the inlet and exit, in order to maintain flow;

(ii) the pump power if the pump efficiency is 85%. (5 marks)

## SECTION D

## THERMODYNAMICS

*Answer any **TWO** questions from this section.*

7. The fuel analysis of a four-cylinder, four stroke petrol engine by weight is C - 90% and H - 11%. The analysis of the exhaust gases by volume are $CO_2$ - 9%, $N_2$ - 79% and $O_2$ - 11%.
The compression ratio of the engine is 18:1. The cylinder bore is 185 mm and the stroke is 450 mm.
At 850 rev/min the brake mean effective pressure is 9.4 bar, and the specific fuel consumption is 0.3 kg /kwh. Taking the atmospheric temperature and pressure as 20°C and 1.7 bar respectively, and the calorific value of fuel as 44 KJ/kg, determine the following when the mechanical efficiency is 90%:

(a) the air fuel ratio; (8 marks)

(b) the indicated power; (7 marks)

(c) the indicated thermal efficiency. (5 marks)

8. In a generating set of a gas turbine the L.P turbine drives the L.P compressor and an alternator, while the H.P turbine drives the H.P compressor. The gas temperature at entry to both turbine stages is 600°C and the air ambiet temperature is 20°C. The pressure ratio of each compressor is 3:1. The mass flow rate is 115 kg/s and the isentropic efficiencies of the compressor and the turbines are 82% and 90% respectively.
A heat exchanger of effectiveness 70% is fitted in the system. Taking the compression index as 1.4, the Cp air = 1.005 KJ/Kg k and Cp gas = 1.15 KJ/kgk and assuming complete cooling; when expansion index is 1.33.

(a) Draw the plant and T-S diagram and determine the; (4 marks)

(b) The net power output. (13 marks)

(c) The thermal efficiency. (3 marks)

9. (a) Show that the heat transfer Q for a counter flow heat exchanger is given by;

$$Q = \mu A(L.M.T.D).$$

where; $\mu$ is the overall heat transfer coefficient
A is the mean surface area of the tube.
L.M.T.D is the Logarithmetic Mean Temperature Difference.
(15 marks)

(b) Oil enters the tube of a double pipe heat exchanger at 100°C and leaves at 20°C. The oil is cooled by a counter current flow of water available at 15°C. The water and oil flow rates are 4 kg/min and 11.2 kg/min respectively. The overall heat transfer coefficient is 1.640 kw/m$^2$k and the tube has a mean diameter of 125 mm. Taking the specific heat capacities of oil and water as 2.2 KJ/Kgk, and 4.2 KJ/kg k respectively; determine the length of the tube required. (5 marks)

10. (a) Define the term diagram efficiency as used in steam turbines. (2 marks)

(b) Show that for an impulse turbine with symetrical blades and with blade velocity coefficient equal to unity, the diagram efficiency ($\eta_d$) is given by;

$$(\eta_d) = \frac{4b}{ai}\left(\text{Cos}\alpha i - \frac{b}{ai}\right)$$

where; b is the blade velocity
$\alpha i$ is the nozzle inlet angle
ai is the steam inlet angle. (8 marks)

(c) Steam from nozzles of a single wheel impulse turbine discharges with a velocity of 430 m/s to the plane of a wheel. The blade wheel rotates at 280 rev/min, and the blade diameter is 1.2 m.
The blade angles at inlet and outlet are 40° and 35° respectively. If the absolute velocity at the exit is radial and the loss of relative velocity due to friction is 15%, determine:

(i) nozzle angle;
(ii) power developed for steam consumption of 650kg/h;
(iii) the diagram efficiency. (10 marks)