THE OPEN UNIVERSITY OF SRI LANKA
BACHELOR OF TECHNOLOGY HONOURS IN ENGINEERING
FINAL EXAMINATION
MEX6232/MEX6332 - VEHICLE DYNAMICS AND DESIGN OF AUTOMOTIVE COMPONENTS

DATE : 6th December 2017
TIME : 09:30 Hrs to 12:30 Hrs
DURATION : 03 hours

: This question paper consists of seven (07) questions. You are required to answer only five (05) questions. All questions carry equal marks.

Question 01

A four stroke, four cylinder diesel engine is developing 45 kW at 4600 rpm. The Indicated mean effective pressure is 0.4 N/mm^2 and the mechanical efficiency is 87 %. Assume the following:
The maximum pressure to be 15 times the indicated Mean Effective Pressure
Allowable stress of the cylinder material as 60 N/mm^2
Stroke is 1.2 times the bore diameter.

Determine:
1. bore and length of the cylinder
2. thickness of the cylinder head

Question 02

(a) Calculate the power required and overall transmission ratio between the engine and the road wheels for a truck travelling on a level road, using the following data.

Mass of the truck	-	2,500 kg
Speed of the truck	-	40 km/h
Tractive resistance against the motion	-	0.2 N/kg
Diameter of the road wheel	-	1.2 m
Engine speed	-	1,800 rev/min
Transmission efficiency of the truck	-	0.85

(b) When the engine transmitting three times the power calculated in (a) at 1,800 rev/min, with the throttle at fully open position determine:

i. The maximum truck speed in km/hr along a 10^0 slope
ii. The overall gear ratio required.

Question 03

Estimate the suitability of an automotive axle of 160 mm diameter, made of a material with a endurance strength (complete stress reversal), σ_e = 420 MPa and a tensile yield strength of 450 MPa. The member is subjected to a varying axial load from W_{min} = - 400 kN to W_{max} = 900 kN and has a stress concentration factor = 1.8. Use factor of safety as 2.0 (Refer to the datasheet given when answering this question and make necessary assumptions).

Question 04

Compare the performance of the two vehicles given bellow in terms of fuel consumption for a total distance of 3km travel. You may assume that the average massof a passenger is75 kg,

Type	Hybrid Car	Conventinoal Family Sedan
Coefficient of rolling resistance	0.1	0.1
Gross weight	1325 kg	1000 kg
Average speed	60 km/h	50 km/h
Frontal projected area	1.2	0.85
Aerodynamic drag coefficient	0.26	0.3
No of passengers including driver	3	2
Average fuel consumpton of power plant	0.125 kg/kWh	0.225 kg/kWh

Question 05

A motorcar of mass of 800 kg, having spring of stiffness, k= 7 x 10^4N/m and a damper of unknown damping coefficient, is observed to vibrate perpendicular to the wheel base and track with a 12 mm amplitude, while the road excitation vibration has a maximum amplitude of only 4 mm (at resonance). Calculate the damping constant.

Question 06

Explain the terms oversteer and understeer with respect to the dynamic behaviour of a vehicle. Explain how the degree of understeer/oversteer is determined using constant radius method experimentally.

Question 07

The carriage springs of a motor vehicle carry a total load of 4000 N with equal springing at front and rear and with the combined spring rate of 80000 N/m. Calculate the frequency of vertical natural vibration with the dampers removed. If the dampers are adjusted to give a total damping coefficient98000 Ns/m. calculate the frequency of damped vibration.

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Data Sheet

1. *Wear Tooth Load for gears*

$W_w = D_p . b . Q . K$

where W_w = Maximum or limiting load for wear in newtons.
D_p = Pitch circle diameter of the pinion in mm,
b = Face width of the pinion in mm,
Q = Ratio factor

$$= \frac{2 \times V.R}{V.R + 1} = \frac{2T_G}{T_G + T_P}, \text{ for external gears}$$

$$= \frac{2 \times V.R}{V.R - 1} = \frac{2T_G}{T_G + T_P}, \text{ for internal gears.}$$

V.R. = Velocity ratio = T_G / T_p,
K = Load-stress factor (also known as material combination factor) in N/mm^2.

2. The thickness of a cylinder wall

The thickness of a cylinder wall (t) is usually obtained by using a thin cylindrical formula, i.e.

$$t = \frac{p \times D}{2\sigma_c} + C$$

where
p = Maximum pressure inside the cylinder in N/mm^2,
D = Inside diameter of the cylinder or cylinder bore in mm,
σ_c = Permissible circumferential or hoop stress for the cylinder material in MPa or N/mm^2.
C = Allowance for re-boring.

The allowance for re-boring (C) depending upon the cylinder bore (D) for I. C. engines is given in the following table:

D (mm)	75	100	150	200	250	300	350	400	450	500
C (mm)	1.5	2.4	4.0	6.3	8.0	9.5	11.0	12.5	12.5	12.5

3. *Design of Cylinder Head*

The cylinder head may be approximately taken as a flat circular plate whose thickness (t_h) may be determined from the following relation:

$$t_h = D\sqrt{\frac{C.p}{\sigma_c}}$$

where

D – Cylinder bore in mm,
p - Maximum pressure inside the cylinder in N/mm^2,
σ_c - Allowable circumferential stress in MPa or N/mm^2. It may be taken as 30 to 50 MPa,
C - Constant whose value is taken as 0.1.

4. *Design of the Piston Crown*

The thickness of the piston head for strength
The thickness of the piston head (t_H), according to Grashoff's fornmla is given by

$$t_H = \sqrt{\frac{3p.D^2}{16\sigma_t}} (\text{in mm})$$

Where,

p = Maximum gas pressure or explosion pressure in N/mm^2,
D = Cylinder bore or outside diameter of the piston in mm, and
σ_t = Permissible tensile stress for the material of the piston in MPa or N/mm^2

Design of piston head for heat transfer
On the basis of second consideration of heat transfer

$$t_H = \frac{H}{12.56k(T_C - T_E)} (\text{in mm})$$

5. Design Against fatigue

Gerber method

$$\frac{1}{F.S} = \left(\frac{\sigma_m}{\sigma_u}\right)^2 F.S. + \frac{\sigma_v \times K_f}{\sigma_e}$$

The Goodman criteria

$$\frac{1}{F.S} = \frac{\sigma_m}{\sigma_u} + \frac{\sigma_v \times K_f}{\sigma_e}$$

The Soderberg criteria

$$\frac{1}{F.S.} = \frac{\sigma_m}{\sigma_y} + \frac{\sigma_v \times K_f}{\sigma_e}$$

where F.S. = Factor of safety,
σ_m = Mean stress.
σ_u = Ultimate stress,
σ_v = Variable stress.
σ_e = Endurance limit for reversed loading,
K_f = Fatigue stress concentration faction

END.