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

DATE : 14th December 2016
TIME : 9.30 hrs – 12.30hrs
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

Typical parameters for a vehicle are given below.

Speed of the vehicle	- 40 km/h
Wheel base	- 2640 mm
Height of the center of gravity above ground	- 610 mm
Distance from the rear axle to the center of gravity	- 1120 mm
Coefficient of friction between tyre and the road	- 0.4

Calculate the stopping distance when brakes are applied,

i. Only on front wheels
ii. Only on rear wheels
iii. On all four wheels

Question 02

The following observations were made in respect of a passenger car.

Curb weight:		
on the front axle	-	6,700N
on the rear axle	-	5,400N
Wheelbase	-	2,400mm
Speed of the car	-	45 km/hr
Overall length of the car	-	4,100mm
Overall width of the car	-	1,600mm
Overall height of the car	-	1,300mm
Aerodynamic drag coefficient of the car	-	0.38
Transmission efficiency of the car	-	0.80
Coefficient of rolling resistance between road and tyre-wheel	-	0.02
Ambient pressure	-	$1.03 \times 10^5 N/m^2$
Ambient temperature	-	30^0C
Gas constant	-	0.287 kJ/kg.K

Determine:

i. Fore/aft position of the centre of gravity of the car.
ii. Aerodynamic drag resistance.
iii. Rolling resistance.
iv. Power developed by the engine under the given conditions.

Question 03

(a) If the wear pattern shown in Figure Q3(a) is of a left front wheel of a vehicle, explain the method to rectify this problem.

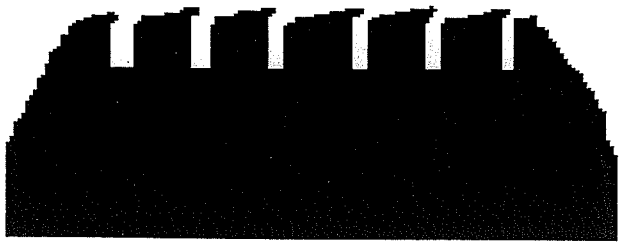


Figure Q3 (a)

(b) 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.

(c) The figure Q3(b) show, generation of forces in the contact patch when a wheel is accelerated. Explain the rolling resistance behavior of a tyre with the increase of linear velocity.

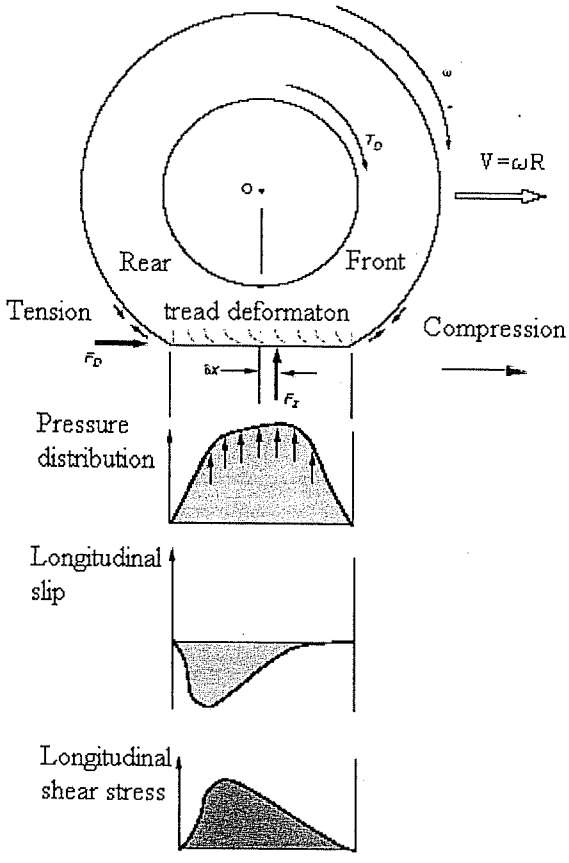


Figure Q3 (b)

Question 04

(a) Briefly explain the main parameters that affect the adhesion between tyre and road.
(b) Using a rough sketch, explain the variation of rolling resistance with linear speed for radial ply and bias ply tyres.
(c) Using a rough sketch, explain the variation of adhesion of a new tyre with treads and a bold tyre on a wet surface.

Question 05

Estimate the suitability of an automotive axle of 110 mm diameter, made of a material with a fatigue strength (complete stress reversal), σ_e = 260 MPa and a tensile yield strength of 450 MPa. The member is subjected to a varying axial load from W_{min} = - 400 x 10^3 N to W_{max} = 900 x 10^3 N and has a stress concentration factor = 1.8. Use factor of safety as 2.0 (You may refer to the datasheet given when answering this question and make necessary assumptions).

Question 06

A four stroke four-cylinder diesel engine is developing 38 kW at 3800 r.p.m. The Indicated mean effective pressure is 0.35 N/mm^2 and the Mechanical efficiency is 82 %. You may assume the following:
The maximum pressure to be 10 times the indicated men effective pressure.
Allowable stress of the material as 42 N/mm^2.
Stroke is 1.5 times the bore diameter.

Determine:

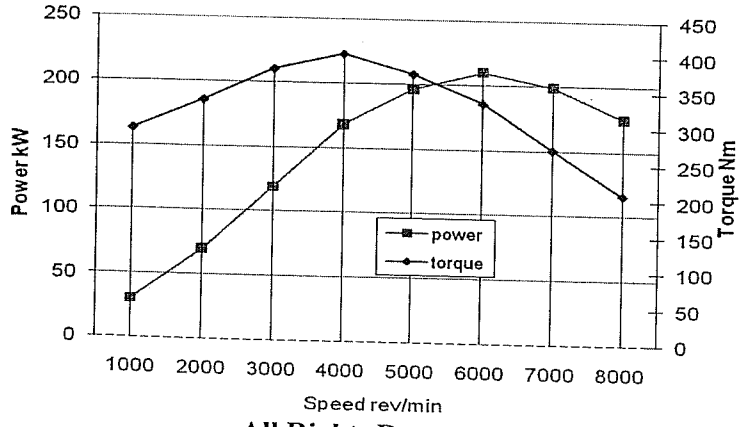
1. bore and length of the cylinder;
2. thickness of the cylinder head

(You may refer to the datasheet given when answering this question).

Question 07

An engine of a vehicle was tested at full throttle on a chassis dynamometer and the following performance curve was generated. The testing revealed that the rolling resistance and the aerodynamic drag resistance is given by155+0.35 V and 0.16 V^2 respectively. The total mass of the car is 1500 kg.

(a) if the vehicle was tested in the top gear and the maximum speed at 5000 rev/min, the speed of the vehicle is 142 km/h
   i. Determine the overall transmission efficiency and the overall gear ratio
   ii. Acceleration at maximum engine torque condition.



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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