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THE OPEN UNIVERSITY OF SRI LANKA
BACHELOR OF TECHNOLOGY - LEVEL 06
FINAL EXAMINATION – 2010/2011
MEX 6332 : VEHICLE DYNAMICS AND DESIGN OF AUTOMOTIVE COMPONENTS
DATE : 31ST MARCH 2011
TIME : 14:00HRS TO 17:00HRS
DURATION : THREE HOURS

Instructions. : This question paper consists of two parts. Part A consists of two (02) questions and part B consists of six (06) questions. You are required to answer only five (05) questions selecting at least one (01) question from part A. All questions carry equal marks. Please read the information given in appendix 01 before you answer the question paper.

Part A

Question 01.

Determine the mass and diameter of a cast iron flywheel for a four stroke Internal Combustion Engine that develops 70 kW at 1800 rev/min if,

- Fluctuation of speed is 3%
- The work done during power stroke is 1/3 more than the average work done during the whole cycle
- Maximum torque on the crank shaft is twice the mean torque.
  Assume that the Density of cast iron is 7220 kg/m^3 and the Tensile Strenght is 5.2x10^6 N/m^2

Question 02

Starting from fundamentals show that the maximum velocity of a vehicle running on a banked track is given by $V = \sqrt{gr\dfrac{\sin\theta + \mu\sin\theta}{\cos\theta - \mu\sin\theta}}$ where,

θ – inclination of wheel axle to the horizontal
r – radius of curved path measured at centre of gravity of the vehicle
μ – coefficient of adhesion between tyre and wheel

Parameters for two vehicles moving on a banked track are given in table 2. Estimate which vehicle will over turn first. The inclination of track to the horizontal is 10^0 and radius of curvature at centre of gravity of the vehicle is 8 meters.

Table 2

Parameter	Passenger car	truck
Weight (kg)	5000	1200
Wheel track (m)	1.4	1.2
Wheel base (m)	4.5	2.5
Location of centre of gravity above ground (m)	0.35	0.4
Coefficient of adhesion between tyre and wheel	1.4	1.4
Location of centre of gravity from front axle (m)	1.5	1.2

PART B

Question 03

An engine develops a maximum torque at a speed of 3,800 rev/min and the corresponding brake power is 45 kW. The lowest gear ratio of transmission is 2.5, and the final drive gear ratio is 4:1. The effective wheel diameter is 800 mm and the coefficient of adhesion between the tyre and the road surface is 0.1. Assuming that the axle shaft is subjected to torsional stresses only, determine the diameter of the shaft. The maximum permissible shear stress for the material of the shaft is 380 MN/m^2.

Also calculate the load on the wheel.

Question 04

Show that the maximum torque (T) transmitted through a plate clutch having n pairs of contacting surfaces under uniform pressure conditions is given by

$$T = \frac{2}{3}\mu n P\left[\frac{r_1^3 - r_2^3}{r_1^2 - r_2^2}\right]$$

where μ - coefficient of friction between the plate surfaces
P - axial force
r_1 - outer radius of the plate
r_2 - inner radius of the plate

A single plate clutch with one pair of contact surfaces transmits 80 kW from an engine running at 1,800 rev/min. Assuming that the pressure distribution is limited to 0.12 N/mm^2 and that the ratio of the outer radius of the clutch plate to the inner radius of the plate is 1.6, determine the outer and inner radii of the clutch plate. Assume that the coefficient of friction between the contact surfaces is 0.25.

Question 05

A motor vehicle of mass of 1,800 kg has an engine which develops 70 kW when the vehicle is travelling on a level track at a steady speed of 110 km/h in top gear. Under these conditions the engine speed is 4200 rev/min and the transmission efficiency is 90%. The resistance (R) to the motion of the vehicle, $R = \alpha + 0.3V^{1.5}$ (N), where V is the speed of the vehicle in km/h and α is a constant. Calculate the value of the constant α. Also determine the gear ratio of the final drive if the wheel radius is 300 mm.

The vehicle now climbs a gradient of inclination 10^0, at a uniform speed of 60 km/h in the second gear with an overall transmission efficiency of 85%. Determine the engine power required to climb the gradient.

Question 06

a) Explain the terms ride and handling with respect to vehicle dynamics

b) Human sensitivity to ride frequency is associated with the natural oscillations of an adult human body during walking. An adult walks at the rate of about 70 to 90 steps per minute, and the chest moves up and down about 5 mm (amplitude) with each step. Analytically compare the natural frequency and static deflection of a standard sedan of 1800 kg curb weight with a 450 kg curb weight light vehicle. Assume that the natural frequency of standard sedan is 1.2 Hz and both vehicles carry four 80 kg occupants aboard.

Question 07

a) The contact behaviour of the tyre and road can be explained as a combination of adhesion and hysteresis. Explain the effect of adhesion and hysteresis with regard to rolling resistance of a tyre.

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 experimentally using constant radius method.

Question 08

a) Using a neat sketch explain the variation of normal stress and shear stress between the tyre and wheel when a vehicle is accelerating
b) Explain the terms camber, caster and toe in-out with respect to a passenger car
c) Explain the effect of caster angle on self-rightening of an automobile steering system
d) The variation of rolling resistance for bias ply and radial ply tyres are shown in figureQ8. Explain why the coefficient of rolling resistance of a radial ply tyre is lower than that for a bias ply tyre.

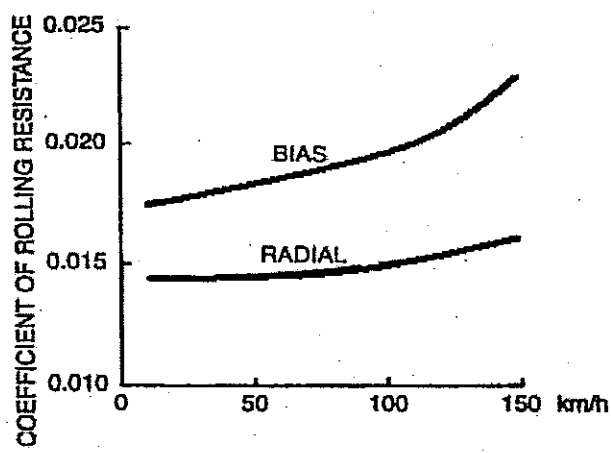


Figure Q8 – Variation of rolling resistance

Appendix 01 – Useful information

i. **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, and
C = Constant whose value is taken as 0.1.

ii. **The thickness of the piston head (t_H), according to Grashoff's formula 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 bending (tensile) stress for the material of the piston in MPa or N/mm^2. It may be taken as 35 to 40 MPa for grey cast iron, 50 to 90 MPa for nickel cast iron and aluminum alloy and 60 to 100 MPa for forged steel.

iii. **For a Flywheel, the hoop stress σ_t is given by,**

$$\sigma_t = \rho.R^2.\omega^2 = \rho.v^2$$

Where,

σ_t - tensile strength
v - linear velocity of the fly wheel
ω- angular velocity of the fly wheel
R - radius of the flywheel
ρ - density of the flywheel material

END

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