THE OPEN UNIVERSITY OF SRI LANKA
BACHELOR OF TECHNOLOGY - LEVEL 06
FINAL EXAMINATION – 2011/2012
MEX 6332 : VEHICLE DYNAMICS AND DESIGN OF AUTOMOTIVE COMPONENTS
DATE : 22nd March 2012
TIME : 1400 hrs to 1700 hrs
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.

Due to scarcity of fossil fuel and environmental pollution, engineers are looking for ways to increase the fuel economy of passenger cars. One major step towards achiving high fuel economy is with hybrid transmission systems. However, a research shows that 80% journeys are made with only one or two people in a car. If following information is given, analytically compare a hybrid sedan with a two seater small car for fuel economy. You may assume that the weight of an average passenger is 75 kg. You are reqired to clearly state your assumptions.

Parameter	Hybrid sedan	Small car
Gross weight of a car	1325 kg	730 kg
Fuel consumption	0.125 kg/kWh	0.225 kg/kWh
No of passengers	4	2
Average speed	60 km/h	50 km/h
Aerodynamic drag coefficient	0.26	0.3
Frontal projected area	1.2	0.85
Coefficient of rolling resistance	0.01	0.01

Question 02

An engine of a vehicle was tested on a chassis dynamometer and the performance curve given in Figure Q2 was generated. The testing revealed that the rolling resistance and the aerodynamic drag resistance is given by155+0.35 V and 0.11 V^2 respectively where V is the speed of the vehicle in km/h. The total mass of the car is 1500 kg. If the vehicle was tested in the top gear and the maximum speed at 5000 rev/min, is 142 km/h, determine

(i) Overall transmission efficiency and the overall gear ratio
(ii) Acceleration at maximum engine torque condition.

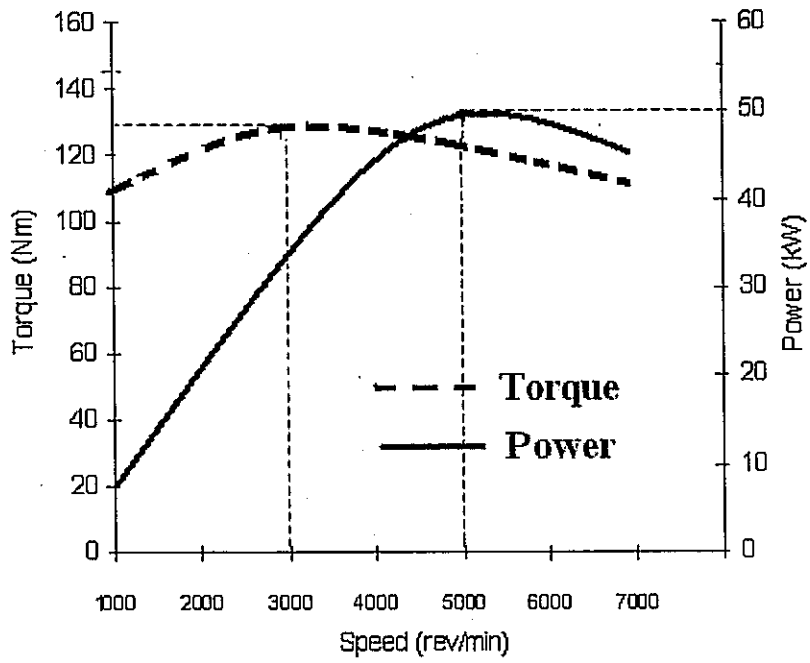


Figure Q2

PART B

Question 03

Starting from fundamentals, derive an equation to determine the maximum velocity of a vehicle running on a banked track for over turning in terms of:

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 Q3. Estimate which vehicle will overturn 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 Q3

Parameter	**Passenger car**	**truck**
Weight (kg)	1200	2400
Wheel track (m)	1.2	1.4
Wheel base (m)	2.5	2.5
Location of centre of gravity above ground (m)	0.35	0.35
Coefficient of adhesion between tyre and wheel	1.4	1.4
Location of centre of gravity from front axle (m)	1.2	1.2

Question 04

a. Starting from fundamentals show that under uniform pressure conditions, the torque transmitted by a clutch is given by

$$T = \frac{2}{3}\mu W\left[\frac{(r_1)^3 - (r_2)^3}{(r_2)^2 - (r_2)^2}\right]$$

b. Design a single plate clutch, effective on both sides, to transmit 45 kW at 3600 rev/min.
You may use the following data for the design.

Coefficient of friction between the plate and the pressure plate	- 0.25
Ratio of radii (outer and inner)	- 1.3
Maximum pressure	- 0.1 N/mm^2.

Question 05

Design a suitable propeller shaft assuming that the shaft is subjected to torsion only, for a vehicle with following specifications.

Maximum power developed by the engine	- 75 kW
Speed at which the maximum power is developed	- 5400 rev/min
Gear ratio at the first gear	- 2.5
Gear ratio at the reverse gear	- 2.8
Final drive ratio	- 4
Effective road wheel diameter	- 0.8 m
Coefficient of friction between tyre and road	- 0.75
Maximum permissible shear stress of the shaft material	- 5.25 x 10^8 N/m^2

(Assume that the shaft is of constant cross section)

Question 06

A motor vehicle of mass of 1,500 kg has an engine which develops 60 kW when the vehicle is travelling on a level track at a steady speed of 120 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°, at a uniform speed of 50 km/h in the second gear with an overall transmission efficiency of 88%. Determine the engine power required to climb the gradient.

Question 07

a. Starting from fundamentals, show that the acceleration of a piston in a reciprocating engine is given by

$$a_p = \omega^2 r\left[\cos\theta + \frac{\cos 2\theta}{n}\right]$$

where, n is the ratio of connecting rod length to the crank radius.

b. Suppose you are designing an engine and the basic parameters of the engine are as follows.

Type of engine	Spark ignition
No. of cylinders	4
Firing order	1-3-4-2
Bore diameter of the cylinder	72 mm
Stroke length	80 mm
Connecting rod length	124 mm

Determine the maximum allowable speed of the engine, if the maximum velocity of a piston is not to exceed 25 m/s.

Question 08

a) Using a neat sketch explain the typical contact patch for a radial ply and cross ply tyres separately.
b) Referring to the sketch drawn in (a), compare and explain the variation of rolling resistance for radial ply tyres with cross ply tyres.
c) In a one graph show the variation of rolling resistance for radial ply and cross ply tyres with speed and explain this behaviour.
d) Explain the effect of caster angle on self-rightening effect of an automobile steering system.

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 taeken 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

iv) Density of air – 1.25 kg/m^3

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

END

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