

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering



0024

Study Programme : Bachelor of Science Honours in Engineering
Name of the Examination : Final Examination
Course Code and Title : **DMX5210 Vehicle Dynamics and Design of Automotive Components**
Academic Year : 2024/25
Date : 10th March 2026
Time : 1330-1630h
Duration : 3 hours

INDEX NO:

.....

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of Five (5) questions in Five (5) pages.
3. Answer all questions.
4. All questions carry equal marks.
5. Answer for each question should commence from a new page.
6. This is a Closed Book Test (CBT).

Question 01

- I. Figure Q1 shows the hypothetical power (P) and torque (T) characteristics of a motor vehicle engine plotted against engine speed (ω).

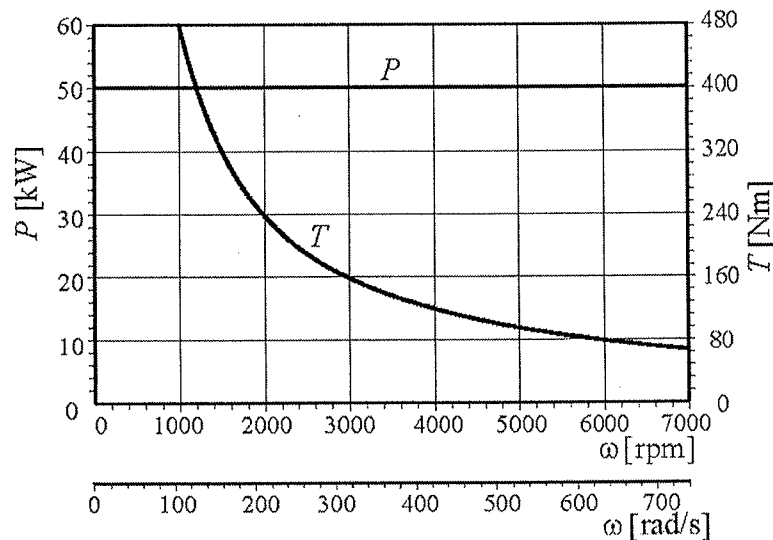


Figure Q1: Hypothetical power (P) and torque (T) for a Vehicle

- a) With reference to Figure Q1, briefly explain why constant power output across all engine speeds is desirable for a vehicle 3 marks
- b) With reference to Figure Q1, explain why a real internal combustion engine cannot maintain constant power across all engine speeds 3 marks
- c) Using your answers to (a) and (b), explain why a multi-ratio gearbox is necessary in a vehicle powered by a real internal combustion engine 3 marks
- II. A front-wheel drive vehicle with a manual transmission has a mass of 1,500 kg and the engine produces a maximum torque of 220 Nm. The vehicle is operating in 2nd gear with a gearbox ratio of 2.80 and a final drive ratio of 3.90. The effective tyre radius is 0.30 m, and the overall driveline efficiency is 0.88. The coefficient of rolling resistance between the tyres and the road surface is 0.02. From the given data, determine the
- a) Tractive effort which is available at the driven wheels. 3 marks
- b) Rolling resistance acting on the vehicle. 2 marks
- c) Maximum gradient angle the vehicle can climb in 2nd gear at constant speed 4 marks
- d) If the gradient becomes steeper than calculated in part (c), explain what the driver has to do and give reasons why this action is necessary. 2 marks

Question 2

- I. Assuming uniform wear, show that the torque T transmitted by a plate clutch is given by:
- $$T = \mu WR$$
- Where:
- W = axial force pressing the surfaces together
- μ = coefficient of friction 11 marks
- R = mean radius of the friction ring
- II. A plate clutch assembly using a single clutch disc has internal and external friction surface diameters of 200 mm and 300 mm respectively. The coefficient of friction between the surfaces is 0.45 and the axial force pressing the surfaces together is 1.5 kN. Assuming uniform wear, determine the power transmitted by the assembly at a rotational speed of 2400 rev/min 9 marks

- I. A vehicle is brought to a workshop with complaints of uneven tyre wear and a consistent pull to the left. A wheel alignment check is carried out, and the report is shown below.

Table 3: Alignment report of a sedan car

Parameter	Specification	Measured (Left)	Measured (Right)
Camber (°)	-0.30 to +0.30	+1.80	+0.20
Caster (°)	+3.50 to +5.50	+4.20	+4.80
Front Toe (mm)	+1.0 to +3.0	+4.5	+2.0
Rear Camber (°)	-1.50 to -0.50	-0.90	-0.85

According to the above alignment report, draw the tyre wear patterns for the following issues

- a) Camber issue 3 marks
 - b) Toe issue 3 marks
 - c) With the aid of a simple sketch, explain what positive camber means and how it is measured. 3 marks
 - d) Using your sketch, explain how this lateral force causes the vehicle to pull to the left. 4 marks
- II. With the aid of a simple top-view sketch, explain the difference between toe-in and toe-out. 3 marks
- III. Explain why most cars are generally set with a slight toe-in rather than toe-out. Give two reasons. 2 marks
- IV. The wheel alignment technician suggests rectifying the camber issue, before the toe adjustment. Give reasons for his argument. 2 marks

- I. A passenger vehicle has a sprung mass of 1,400 kg and an unsprung mass of 210 kg.
- a) Explain the difference between sprung mass and unsprung mass in a vehicle suspension system. Give two examples of components that belong to each category. 3 marks
- b) Explain why a high sprung-to-unsprung mass ratio is desirable for good ride and handling performance. In your answer refer to how unsprung mass affects tyre contact with the road. 3 marks
- II. In vehicle dynamics there is a phenomenon called the wheel hop. This could occur when an automobile wheel drops into a pothole and loses road contact, and unsprung mass is free to oscillate on the suspension spring. During this instance the unsprung mass oscillates at the wheel-hop natural frequency of the suspension system 4 marks
- The wheel-hop natural frequency (f_n) of the unsprung mass (m_u) is given by the following equation

$$f_n = \frac{1}{2\pi} \sqrt{\frac{k}{m_u}}$$

k – spring stiffness
 m_u – Unsprung mass

By using the above equation, explain the reason for compact cars such as Suzuki Wagon R, Toyota Aygo are more susceptible to wheel hop compared to a heavy sedan, if you drive them over a pothole at high speed.

(Hint-Smaller cars have high stiff spring)

- III. A standard sedan of 1,750 kg and a compact car of 500 kg both carry two occupants of 85 kg each. The unsprung mass of both vehicles is 13% of their respective total mass.
- (a) Considering the suspension stiffness (k) for the Sedan is 15 kN/m per wheel and the compact car is 25 kN/m per wheel, calculate the Natural Frequency (f_n) in Hertz (f) for both vehicles using the formula given above. 5 marks

Use **unsprung mass per wheel** ($m_u = 0.13 \times \text{total mass} \div 4$) in the formula above for all calculations in this part.

- (b) Based on the answer for part (a), show that the large sedan would have a better handling stability and tyre contact performance compared to the smaller car. 3 marks
- (c) From the answer you obtained for part (b), explain a possible modification you can do to a compact car, other than changing parameters in the above equation. 2 marks

Question 05

- I. Explain the term crashworthiness with reference to plastic deformation and occupant survival space. 3 Marks
- II. Explain the stiff cage structural concept used in modern vehicle design, Stating referring to the two necessary features that a good stiff cage structure must possess. 3 Marks
- III. In controlled progressive crush design in modern automobiles name the three crush zones and their purpose. 4 Marks
- IV. A vehicle travelling at 50 km/h collides against a rigid barrier and comes to a complete stop. The crumple zone accommodates a displacement of 0.625 m. The seat belt has a backlash distance of 0.156 m and stops the restrained occupant in a further 0.045 s after the backlash phase.
- a) Calculate the time taken for the vehicle to come to a complete stop and the vehicle deceleration in g units. 4 Marks
- b) An unrestrained occupant hit an interior body panel after travelling 0.03m. Calculate the deceleration experienced by the unrestrained occupants in g units and comment on whether this is survivable. 3 Marks
- The restrained occupant continues at constant speed during the backlash phase before the restraint system acts. 3 marks
- c) Calculate the deceleration of the restrained occupant in g units and comment on how this compares to the unrestrained occupant.

All Rights Reserved