



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
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LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 5

LEFEL 5

EXAMINATION PERIOD
JULY 2022

CYFNOD ARHOLIADAU
GORFFENNAF 2022

MODULE CODE: ACHA5013 & ACHA5009
Automotive Chassis Systems & Motorsport Dynamics

SEMESTER 2 RESIT EXAM

TIME: 2 HOURS + SUBMISSION TIME (ONLINE)

ANSWER ALL QUESTIONS

Equipment or materials required – None

Adnoddau neu ddefnyddiau sydd eu hangen – Dim

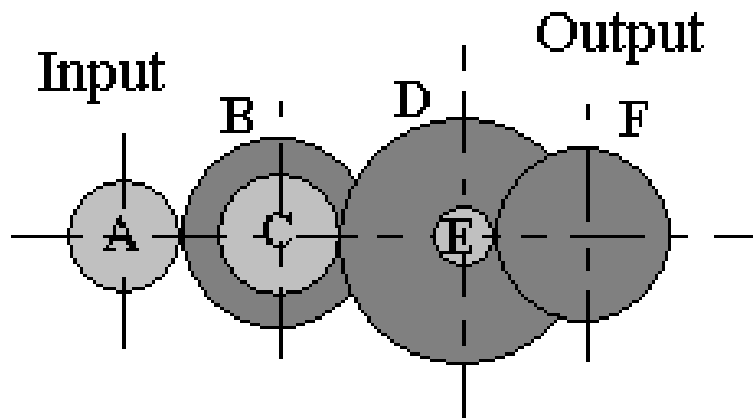
Calculators are permitted.

A 'formula sheet' is provided for reference.

Assume 'g' = 9.81 m/s^2 where relevant.

Answer ALL Questions

Question 1:



Input Torque: 150NM

Input RPM: 2750 (Clockwise)

Efficiency: 86%

Gear A: 26 Teeth

Gear B: 112 Teeth

Gear C: 28 Teeth

Gear D: 130 Teeth

Gear E: 16 Teeth

Gear F: 100 Teeth

- a) For the above compound gear train, calculate the overall gear ratio.

(3 Marks)

- b) Calculate the output rotation speed and direction.

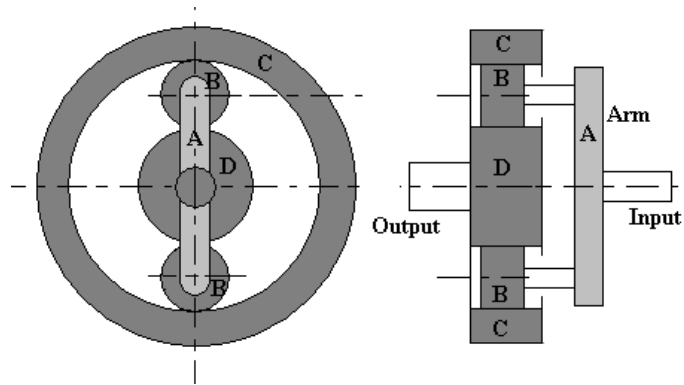
(2 Marks)

- c) Calculate the Input and Output Power figures.

(2 Marks)

- d) Calculate the required Holding Torque to keep the gearbox casing static.

(3 Marks)



Ring Gear C: 244 Teeth

Planet Gears B: 26 Teeth

Sun Gear D: 190 Teeth

Input is Arm (A), Output is Sun Gear (D)

- e) Calculate the overall ratio of the epicyclic gearset for the conditions given above, assuming that the Ring Gear C is held fixed.

(10 Marks)

Question 2:

A vehicle utilises a dry clutch system with a single 2-sided driven plate (giving 2 friction surfaces) of specification:

Inner Diameter: 108mm

Outer Diameter: 200mm

Mu value (friction material to cast iron): 0.36

The clutch uses a linear diaphragm spring with a rate of 1000 N/mm and has a fitted load of 6500N.

a) Based on the **Uniform Pressure Theory**, how much torque could the clutch system transmit:

(4 Marks)

b) If each side of the friction material was worn by 1.75mm, how much torque would the worn clutch system be capable of transmitting?

(4 Marks)

A multiplate clutch pack fitted to a high-performance sports car must be capable of transmitting 300Kw of power at 6500RPM without slipping. The clutch system has the following specifications:

Inner Diameter: 58mm

Outer Diameter: 121mm

Mu Value (carbon ceramic to cast iron): 0.33

The clutch system employs a diaphragm spring with a rate of 800 N/mm and a fitted load of 6000N.

c) Based on the **Uniform Wear Theory**, calculate the number of friction plates required to meet the specification.

(4 Marks)

d) Based on the **Uniform Pressure Theory**, calculate the number of friction plates required to meet the specification.

(4 Marks)

A conical synchroniser gear in a transmission has the following specifications:

Outer diameter: 104mm

Inner Diameter: 92mm

Axial Force: 1400N

Mu value: 0.21

Surface Inclination Angle: 8°

- e) Based on the **Uniform Wear Theory**, calculate the transmittible torque

(4 Marks)

Question 3:

For a vehicle with parameters as follows:

Pedal Ratio: 3.2 : 1

Master Cylinder Diameter: 12.8mm

Slave Cylinder Piston Diameter: 42mm

Number of Slave Cylinders per Corner: 2

Effective Pad Radius: 160mm

Pad Coefficient of Friction: 0.44

Wheel Rolling Radius: 0.28m

Vehicle Mass: 800Kg

Static Mass Distribution F:R: 48%:52%

Static Mass Distribution L:R: 50%:50%

CoG Height: 0.33m

Wheelbase: 2.7m

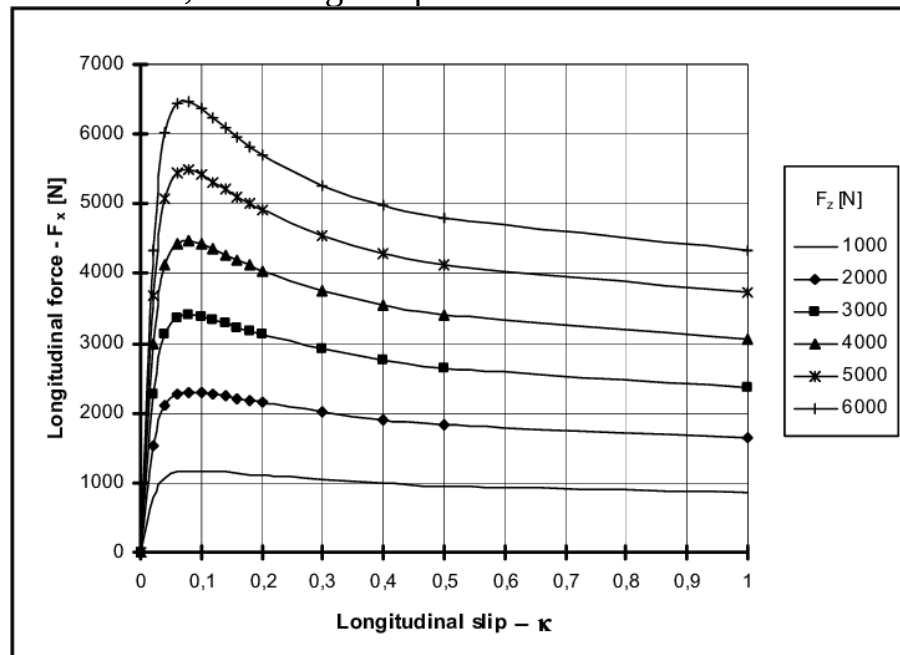
- a) Calculate the longitudinal load transfer (rigid vehicle method) if the vehicle was decelerating at 0.9G.

(2 Marks)

- b) Determine the front axle tyre loads during deceleration.

(3 Marks)

- c) Based on the tyre characteristic graph below, approximate the amount of longitudinal reaction force obtained from a single front tyre during this deceleration event, assuming a slip ratio of 0.1.



(2 Marks)

- d) Using your answer from part C for the maximum longitudinal force a front tyre can generate, calculate the amount of pedal effort that the driver would have to input to utilise the full potential of both front tyres.

(6 Marks)

- e) Assuming that the vehicle is decelerating at $0.9G$ (thus the load transfer from part A is still valid), calculate:

i) The vertical load on a single rear tyre

(2 Marks)

ii) Assuming the front and rear tyres are identical, approximate the longitudinal force a single rear tyre can produce based on this vertical loading, assuming a slip ratio of 0.1 .

(2 Marks)

iii) Based on the front and rear tyre longitudinal reaction forces, calculate the total longitudinal force that can be produced by the vehicle.

(1 Marks)

iv) Calculate the F:R brake distribution that the system would have to be designed for under these conditions.

(2 Marks)

Question 4

For a vehicle of the following specifications:

Mass: 1255Kg

Frontal Area: 1.7 m^2

Coefficient of Drag (Cd): 0.33

Coefficient of Rolling Resistance: 0.015

Maximum Engine Output Power: 154KW

Maximum Power RPM: 6250RPM

Maximum Engine Torque: 190Nm

Maximum Torque RPM: 5000RPM

Drivetrain Efficiency: 86%

Number of forward Gears: 5

Tyre Rolling Radius: 0.29m

- a) Calculate the total tractive resistances when the vehicle is moving at 35m/s. Assume the vehicle is on level ground with no headwind/tailwind.
(4 Marks)
- b) If we assume that 5th gear has a ratio of 0.82, calculate the required final drive ratio to allow the vehicle to achieve a maximum speed of 74m/s in 5th gear, with the maximum speed being achieved at the engine peak power RPM.
(5 Marks)
- c) If the same vehicle was to be pulling away on a 1:3.5 incline, calculate the 1st gear ratio that would be required to overcome tractive resistances.
(5 Marks)
- d) Based on the final drive and 1st gear ratios you have calculated, find the intermediate ratio values for:
 - (1) 2nd Gear
(2 Marks)
 - (2) 3rd Gear
(2 Marks)
 - (3) 4th Gear
(2 Marks)

Level 5 Automotive & Motorsport Dynamics Formula Sheet

Load Transfer:

$$LT_{lat} = \frac{mah}{t}$$
$$LT_{long} = \frac{mah}{w}$$

Braking Systems

$$F_{mcyl} = F_{pedal} * PR$$

$$P = \frac{F_{mcyl}}{A_{mcyl}}$$

$$F_{scyl} = P * A_{scyl} * n$$

$$T = F_{scyl} * \mu * r$$

$$F_w = \frac{T}{R}$$

$$a = \frac{F_w * 2}{m}$$

Flat Plate Clutches

Uniform Pressure Theory:

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

Uniform Wear Theory:

$$T = \frac{\mu W (r_2 + r_1)}{2}$$

Conical Clutches

Uniform Pressure Theory:

$$T = \frac{\mu R}{3 \sin \beta} \frac{[D_o^3 - D_i^3]}{[D_o^2 - D_i^2]}$$

Uniform Wear Theory:

$$T = \frac{\mu W (D_o + D_i)}{4 \sin \beta}$$

Resistive Forces on Vehicle

Aero Resistance:

$$F_{ar} = 0.5 * \rho * C_d * A * V^2$$

Rolling Resistance:

$$F_{rr} = C_{rr} mg \cos \theta$$

Gradient Resistance:

$$F_g = mg \sin \theta$$

Tractive Resistance:

$$TR = \frac{1}{2} \rho C_d A (V + V_o)^2 + mg(\sin \theta + C_{rr} \cos \theta)$$

Gear Systems

$$Power = \frac{2\pi NT}{60}$$

$$Gear\ Ratio = \frac{INPUT\ SPEED}{OUTPUT\ SPEED} = \frac{N_1}{N_2}$$

$$G.R. = \frac{INPUT\ SPEED}{OUTPUT\ SPEED} = \frac{\omega_1}{\omega_2}$$

$$\eta = \frac{Power\ Out}{Power\ In} = \frac{2\pi N_2 T_2 \times 60}{2\pi N_1 T_1 \times 60} = \frac{N_2 T_2}{N_1 T_1}$$

$$T_1 + T_1 + T_3 = 0$$

$$\frac{2\pi R_1 N_1}{60} = \frac{2\pi R_2 N_2}{60} \Rightarrow R_1 N_1 = R_2 N_2$$

$$V = \frac{2\pi RN}{60fn}$$

$$TE = \frac{Tfn_x \eta}{R}$$

$$SR = \frac{Max\ Torque\ RPM}{Max\ Power\ RPM}$$

$$n_x = n_1 * SR^{x-1}$$