

EXAMINATION SOLUTIONS : SESSION 2010 /11

Programme:	BEng Motorsport Engineering and Design	Year:	2
Module/Unit :	Vehicle Dynamics		
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Question No	Question	Marks
1a	Calculate the longitudinal load transfer under 8 m/s^2 longitudinal deceleration $WT = \frac{W_s \times a_x \times H}{L \times g} + \frac{(W_{usf} + W_{usr}) \times a_x \times r}{L \times g}$ $\frac{900 \times 0.42 \times 8}{2.35} + \frac{(48 + 52) \times 8 \times 0.24}{2.35}$ $1286 + 81.7$ Total Weight transfer = 1367 N Weight transfer per wheel = 683 N	4
1 b	Determine vertical loads W_{fb} acting on each individual front wheel, assuming the static load distribution is symmetrical Vertical load = Static load + WT $= ((425 + 48)/2) \times g + 683$ $= 2320 + 683 \text{ N}$ 3003 N/wheel	3
1c	Determine longitudinal load f_{yf} acting on each individual front wheel, Total vertical load / wheel = 2657.6 N Longitudinal load = $(M_s + M_{us}) / 2 \times a_x$ Longitudinal Load = $(900 + 100)/2 \times 8 = 4000 \text{ N/wheel}$	3
1d	Calculate the coefficient of friction μ_{tf} between tyre and road for the front tyres $\mu_{tf} = \text{Longitudinal Load} / \text{Vertical Load}$ $\mu_{tf} = 4000 / 3003$ Front road tyre coefficient = 1.332	2

Continuation Sheet

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Question No	Question	Marks
2a	Calculate the front and rear roll stiffnesses and hence total roll stiffness of the car $K_{\phi t} = \frac{(T_f^2 \times K_{wf})}{2} + \frac{(T_r^2 \times K_{wr})}{2}$ $\frac{1.35^2 \times 75\,000}{2} + \frac{1.38^2 \times 95\,000}{2}$ Giving 68343.75 + 90 459 = 158802.75 Nm/rad	4
2b	Calculate the overturning moment produced by the car when cornering at 8.1 m/s² Overturning moment = Ms a H 820 x 8.1 x 0.32 Giving 2125.4 Nm	2
2c	Calculate the roll angle that would be produced by the car when cornering at 8.1 m/s² Roll angle = 1b/ 1a = 0.01384 rad	2
2d	Ignoring the effect of tyre stiffness calculate the weight transfer that would be produced at front and rear of the car at 8.1 m/s². $WT_{sf} = \frac{\theta \times T_f \times K_{wf}}{2} \quad \text{and} \quad WT_{sr} = \frac{\theta \times T_r \times K_{wr}}{2}$ $\frac{0.013384 \times 1.35 \times 75\,000}{2} \quad \text{and} \quad \frac{0.013384 \times 1.38 \times 95\,000}{2}$ Giving Front 677.57 N and Rear 877.06 N	2

Continuation Sheet

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Question No	Question	Marks
2e	<i>Determine the difference between front and rear load splits and explain how this difference could be used to help predict the effect of suspension setup changes on handling balance</i> As the car is symmetrical about the longitudinal axis the front load split = $2 * 677.57 \text{ N}$ and the rear $2 * 877.059 \text{ N}$ The split difference is therefore 398.98 N This difference would need to be calibrated against the actual vehicle's behaviour. Once this difference value has been associated with a particular behaviour. Subsequently any change in weight transfer produced by a change in setup can be calculated and related to the known behaviour .	2 2
2f	<i>Define the terms oversteer and understeer in the form used by the SAE</i> A vehicle is oversteer at a given trim if the ratio of the steering wheel angle to the overall steering ratio is less than the Ackerman steering angle for a given radius of turn	2
2g	<i>Explain in detail how you would determine the level of oversteer /understeer for the car as it takes the corner.</i> The lateral acceleration and velocity can be used to determine the corner radius with $R = v^2 / a$ The ackerman steering angle steered angle δ is found from $\delta = L / R$ where L = wheel base . The actual steered wheel angle is compared with the ackerman steering angle. If it is greater the car is described as understeer and if less then oversteer.	4