



BACHELORS DEGREE ASSIGNMENT SPECIFICATION

Student name:		Student P number:	
Programme:	BEng Motorsport Engineering and Design BEng Automotive Engineering		
Module:	Motorsport Vehicle Dynamics Vehicle Dynamics	Module Level (4, 5, 6):	5
Module code:	M2X8814	Contribution to Overall Module Assessment (%):	50%
Lecturer:	Roger Dowden	Internal Verifier:	Tim Tudor
Assignment Title:	Steady state cornering analysis	Assignment No (x of x):	1 of 1
Hand Out Date:	2/3/2012	Submission deadline:	26/11/2012

Referencing:	In the main body of your submission you must give credit to authors on whose research your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have read or quoted in order to complete this assignment (e.g. for books: surname of author and initials, year of publication, <u>title of book</u> , edition, publisher: place of publication).			
Disclosure:	I declare that this assignment is all my own work and that I have acknowledged all materials used from the published or unpublished works of other people. All references have been duly cited.			
Student's Signature:	Assignments will not be accepted without a signature here	Date:		
Turnitin: Lecturer to tick to indicate if an electronic version of the assignment must be submitted to Turnitin. Note: the Turnitin version is the primary submission and acts as a receipt for the student. Both electronic and paper versions MUST be submitted by the same deadline. No marks will be released until both submissions are received. Late submission of either the electronic or paper version will result in a late penalty mark. Penalties for late submission: Up to one week late, maximum mark of 40%. Over one week late, Refer. Only Year Tutors and the Programme Director may grant an extension.			YES	
			NO	

Learning Outcomes tested (from module syllabus)	Assessment Criteria To achieve each outcome a student must demonstrate the ability to:
The ability to analyse the kinematic and load transfer characteristics of a competition car under steady state longitudinal and lateral accelerations and to use this to predict vehicle handling behaviour.	Analyse suspension design and setup parameters of specified vehicles and suspension systems to enable the prediction of handling balance to be undertaken and verified for limit cornering.

- Please submit the assignment pages stapled together only – not in polypockets.
- This form (ALL PAGES) **MUST** be at the front of the paper submission. Assignments will not be accepted without this form as it is a requirement that you sign the disclosure regarding referencing convention.
- **DO NOT** put this form into Turnitin or it will match many similarities with other students' submissions.

TASK DESCRIPTION

The aim of this assignment is for you to justify the proposal that '*Calculated wheel load distribution can be used to predict steady state vehicle handling behaviour*'.

If we know that a particular load distribution gives a particular level of understeer then we can, if required, adjust the dynamic wheel load distribution to achieve a required behaviour change.

The first step is to read the relevant literature to see what writers have to say about this. It may not be couched in the same terms, but any references to tyre loads and resulting lateral force, load splits and axle grip will be appropriate.

In class we will work through the theory behind the calculations required and you will use data from our MCR S2000 and a track test to actually make and evaluate the predictions. All required dimensional data will be placed in the Motorsport Vehicle / Vehicle Dynamics module in Moodle.

Tasks

1. Produce two Maths channels in Pi Toolbox using the suspension load cell outputs. Choose a section of data where the car runs at close to steady state lateral acceleration of at least 0.5 g for a period of around 2 seconds and then display the channels for that section of track showing:

- a) Channel 1 Front and rear load splits produced by the sprung mass acting about the roll axis only.
- b) Channel 2 Front axle and rear axle roll angles

Develop the maths channels in a series of sub-channels to make it clear how you have created the final channels and also to make it easier to diagnose any problems with your work. You should make clear the conditions you have defined as steady state lateral acceleration and show the mean lateral acceleration achieved and the mean values over the test period for each of the two Maths channels.

- 2 Determine the Ackermann steering angle for the steady state corner selected from the data set using the following process.

Using the relationship that $\text{Radius} = V^2/a$. Determine the radius of turn for the car when travelling round the corner selected from the data. (Remember that V needs to be in m/s and a in m/s^2 so conversions will have to be made on the measured channels).

Important: The Pi software uses the form $\text{pow}([\text{channel}], 2)$ to square a channel and not $[\text{Channel}]^2$

Then, using Ackerman steering angle = wheelbase / Radius of Turn find the theoretical ackerman steering angle for the car as it negotiates the test corner selected.

Subtract the Ackerman steering angle from actual steered angle to produce a value that could be used to describe the car's steady state handling balance in terms of the SAE definition of understeer and oversteer.

- 3 Construct an Excel spread sheet to calculate wheel load distribution and hence front to rear load split in steady state cornering. The spreadsheet should have the capability for the user to easily change lateral acceleration and to give a solution in the form of a value for the difference between front and rear splits as demonstrated in the Rowley load split calculator. Remember to include static wheel loads in your wheel load calculation. Apply the steady state lateral acceleration you have defined from the track test data to your Excel

spreadsheet to calculate:

- a) The front and rear load splits due to the sprung mass acting about the roll axis alone at the defined lateral acceleration
- b) The front and rear load splits produced when all modes of weight transfer are included
- c) The vehicle roll angle at the defined lateral acceleration

4. Based on the results obtained, and supported by your literature review, justify the proposal.

GUIDANCE FOR STUDENTS IN THE COMPLETION OF TASKS

The objective of the work is to produce a spreadsheet that will enable the difference between inner and outer dynamic wheel loads (the load splits) for front and rear axles to be found for a given lateral acceleration. The difference between the front and rear load splits should be usable as a guide to the expected steady state handling characteristics of the car and the aim of this assignment is for you to demonstrate that it is and justify the stated proposal. The Pi Toolbox Channels created from the track test will enable certain aspects of the spreadsheet analysis to be verified, namely :-

The validity of the height of the CG above the roll axis.

The validity of the load transfer calculations for one mode of weight transfer

If these aspects of the work are verified then greater confidence in the analysis can be obtained.

The track test will also enable a quantitative measure of vehicle steady state handling to be made which can be compared with the prediction.

Follow the standard report format required for all work

The following is provided as a guide to what should be included in five of the sections

Theory/ Research

What current literature has to say about the proposal. Explanation of why load distribution has an influence on handling behaviour. Existing software tools available

Results

- a) Pi Toolbox results for:
 - i) steady state roll angle for a given lateral acceleration
 - ii) front and rear load splits due to sprung mass acting about the roll axis alone.
 - iii) Ackerman steering angle compared with actual steering angle.
- b) Screen dumps of relevant pages of Excel spreadsheet for:
 - i) steady state cornering load split difference for the defined lateral acceleration
 - ii) steady state roll angle for the defined lateral acceleration
front and rear load splits due to sprung mass acting about the roll axis alone.

Analysis

Comparison of roll angle and load split results obtained from Pi and Excel to demonstrate the validity of the CG height measurement and calculations used

Comparison of understeer predicted from calculated load splits with measured, steering based understeer.

Discussion / Evaluation – Justify the proposal that ‘Calculated wheel load distribution can be used to predict steady state vehicle handling behaviour’ using the results of your experimental work and your literature review. .

Conclusions / Recommendation - Discussion on the limitations and the accuracy of the results obtained should also be included here along with discussion on how the simple model created in Task 3 could be developed to better represent actual conditions.

MARKING CRITERIA AND STUDENT FEEDBACK

This section details the assessment criteria. The *extent* to which these are demonstrated by you determines your mark. The marks available for each criterion are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Common Assessment Criteria Applied	Marks available	Marks awarded
1. Research-informed Literature Extent of research and/or own reading, selection of credible sources to support the aim of assignment whilst applying appropriate referencing conventions		
	10	
2. Knowledge and Understanding of Subject Extent of knowledge and understanding of concepts and underlying principles associated with the behaviour of tyres and load distribution relevant to the aim of the assignment		
	10	
3. Analysis Comparison of roll angle and load split results obtained from Pi Toolbox and Excel (to demonstrate the validity of the CG height measurement used) Comparison load split predicted understeer with steering based understeer Evaluation – Discussion on limitations of the accuracy of the results obtained, possible causes of the variations occurring between methods, validity of using load splits as a method of predicting handling behaviour.		
	40	
4. Practical Application and Deployment Screen dumps of relevant pages of your Excel spreadsheet to show steady state roll angle for a given lateral acceleration front and rear load splits due to sprung mass acting about the roll axis alone for verification and steady state cornering load split difference due to all modes of weight transfer for a given lateral acceleration for prediction of handling behaviour. Pi Toolbox results for verification in the form of screen dumps of graphs and charts of steady state roll angle for a given lateral acceleration, front and rear load splits due to sprung mass acting about the roll axis alone and actual steering angle - Ackerman steering angle for handling characterisation		
	30	
5. Skills for Professional Practice individual and collaborative experimental work; Clarity and organisation of your report		
	10	

Assignment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	Late Submission Penalties (tick if appropriate)		%
	Up to one-week late	Max 40%	
	Over one week late	Fail	

COMMON ASSESSMENT AND MARKING CRITERIA

	OUTRIGHT FAIL	UNSATISFACTORY	SATISFACTORY	GOOD	VERY GOOD	EXCELLENT	EXCEPTIONAL
Assessment Criteria	0-29%	30-39%*	40-49%	50-59%	60-69%	70-79%	80-100%
1. Research-informed Literature Extent of research and/or own reading, selection of credible sources, application of appropriate referencing conventions	Little or no evidence of reading. Views and findings unsupported and non-authoritative. Referencing conventions largely ignored.	Poor evidence of reading and/or of reliance on inappropriate sources, and/or indiscriminate use of sources. Referencing conventions used inconsistently.	References to a limited range of mostly relevant sources. Some omissions and minor errors. Referencing conventions evident though not always applied consistently.	Inclusion of a range of research-informed literature, including sources retrieved independently. Referencing conventions mostly consistently applied.	Inclusion of a wide range of research-informed literature, including sources retrieved independently. Selection of relevant and credible sources. Very good use of referencing conventions, consistently applied.	A comprehensive range of research informed literature embedded in the work. Excellent selection of relevant and credible sources. High-level referencing skills, consistently applied.	Outstanding knowledge of research-informed literature embedded in the work. Outstanding selection of relevant and credible sources. High-level referencing skills consistently and professionally applied.
2. Knowledge and Understanding of Subject Extent of knowledge and understanding of concepts and underlying principles associated with the discipline.	Major gaps in knowledge and understanding of material at this level. Substantial inaccuracies.	Gaps in knowledge, with only superficial understanding. Some significant inaccuracies.	Evidence of basic knowledge and understanding of the relevant concepts and underlying principles.	Knowledge is accurate with a good understanding of the field of study.	Knowledge is extensive. Exhibits understanding of the breadth and depth of established views.	Excellent knowledge and understanding of the main concepts and key theories. Clear awareness of challenges to established views and the limitations of the knowledge base.	Highly detailed knowledge and understanding of the main theories/concepts, and a critical awareness of the ambiguities and limitations of knowledge.
3. Analysis Analysis, evaluation and synthesis; logic, argument and judgement; analytical reflection; organisation of ideas and evidence	Unsubstantiated generalisations, made without use of any credible evidence. Lack of logic, leading to unsupportable/missing conclusions. Lack of any attempt to analyse, synthesise or evaluate.	Some evidence of analytical intellectual skills, but for the most part descriptive. Ideas/findings sometimes illogical and contradictory. Generalised statements made with scant evidence. Conclusions lack relevance.	Evidence of some logical, analytical thinking and some attempts to synthesise, albeit with some weaknesses. Some evidence to support findings/views, but evidence not consistently interpreted. Some relevant conclusions and recommendations, where relevant	Evidence of some logical, analytical thinking and synthesis. Can analyse new and/or abstract data and situations without guidance. An emerging awareness of different stances and ability to use evidence to support the argument. Valid conclusions and recommendations, where relevant	Sound, logical, analytical thinking; synthesis and evaluation. Ability to devise and sustain persuasive arguments, and to review the reliability, validity & significance of evidence. Ability to communicate ideas and evidence accurately and convincingly. Sound, convincing conclusions / recommendations.	Thoroughly logical work, supported by evaluated evidence. High quality analysis, developed independently or through effective collaboration. Ability to investigate contradictory information and identify reasons for contradictions. Strong, persuasive, conclusions, justifiable recommendations.	Exceptional work; judiciously selected and evaluated evidence. Very high quality analysis, developed independently or through effective collaboration. Ability to investigate contradictory information and identify reasons for contradictions. Highly persuasive conclusions
4. Practical Application and Deployment Effective deployment of appropriate methods, materials, tools and techniques; extent of skill demonstrated in the application of concepts to a variety of processes and/or contexts; formulation of innovative and creative solutions to solve problems.	Limited or no use of methods, materials, tools and/or techniques. Little or no appreciation of the context of the application.	Rudimentary application of methods, materials, tools and/or techniques but without consideration and competence. Flawed appreciation of the context of the application.	An adequate awareness and mostly appropriate application of well established methods, materials, tools and/or techniques. Basic appreciation of the context of the application.	A good and appropriate application of standard methods, materials, tools and/or techniques. Good appreciation of the context of the application, with some use of examples, where relevant.	A very good application of a range of methods, materials, tools and/or techniques. Very good consideration of the context of the application, with perceptive use of examples, where relevant. Evidence of some innovation and creativity.	An advanced application of a range of methods, materials, tools and/or techniques. The context of the application is well considered, with extensive use of relevant examples. Application and deployment extend beyond established conventions. Innovation and creativity evident throughout.	Outstanding levels of application and deployment skills. Assimilation and development of cutting edge processes and techniques.
5. Skills for Professional Practice Demonstrates attributes expected in professional practice including: individual initiative and collaborative working; deployment of appropriate media to communicate (including written and oral); clarity and effectiveness in presentation and organisation.	Communication media is inappropriate or misapplied. Little or no evidence of autonomy in the completion of tasks. Work is poorly structured and/or largely incoherent.	Media is poorly designed and/or not suitable for the audience. Poor independent or collaborative initiative. Work lacks structure, organisation, and/or coherence	Can communicate in a suitable format but with some room for improvement. Can work as part of a team, but with limited involvement in group activities. Work lacks coherence in places and could be better structured.	Can communicate effectively in a suitable format, but may have minor errors. Can work effectively as part of a team, with clear contribution to group activities. Mostly coherent work and is in a suitable structure.	Can communicate well, confidently and consistently in a suitable format. Can work very well as part of a team, with very good contribution to group activities. Work is coherent and fluent and is well structured and organised.	Can communicate professionally and, confidently in a suitable format. Can work professionally within a team, showing leadership skills as appropriate, managing conflict and meeting obligations. Work is coherent, very fluent and is presented professionally.	Can communicate with an exceptionally high level of professionalism. Can work exceptionally well and professionally within a team, showing advanced leadership skills. Work is exceptionally coherent, very fluent and is presented professionally.

Student Self Evaluation Form

Student name:		Student P number:	
Programme:		Year of programme	2
Assignment Title:	Steady state cornering analysis		

This section repeats in brief the common assessment criteria detailed on previous pages. The *extent* to which these are demonstrated by you determines your mark. Using these criteria, tick the box that best indicates the level of achievement you feel you have achieved with regard to each of them.

Common Assessment Criteria Applied	Level of Achievement						
	REFER		3 rd	2:2	2:1	1 st	1 st
	OUTRIGHT FAIL	UNSATISFACTORY	SATISFACTORY	GOOD	VERY GOOD	EXCELLENT	EXCEPTIONAL
1. Research-informed Literature	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐
2. Knowledge and Understanding of Subject	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐
3. Analysis	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐
4. Practical Application and Deployment	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐
5. Skills for Professional Practice	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐

PLEASE COMMENT ON AREAS IN WHICH YOU FEEL THAT YOU HAVE PERFORMED WELL	PLEASE COMMENT ON AREAS YOU FEEL THAT YOU NEED TO DEVELOP

Student's Name		Date	
Student's Signature			