



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

Examination Answer Books

12 Pages

Instructions to Candidates

1. Please give the information requested in the boxes below.
2. Enter your name in the space provided to the right, fold over and seal down (using the label provided) to hide your name.
3. The answers must be legibly written. The Examiners can either ignore illegible script or have it typed and the expense of typing charged to the candidate.
4. Write your answers in ink.
5. Begin each answer on a fresh page. Do all rough work in the answer book and cross it through.
6. No part of this book is to be torn out; it must be handed in complete.
7. If more books than one are used, fasten them together using the tags available from the invigilator(s).
8. Every book must be handed in. In no circumstances may answer books, used or unused, be taken out of the examination venue.

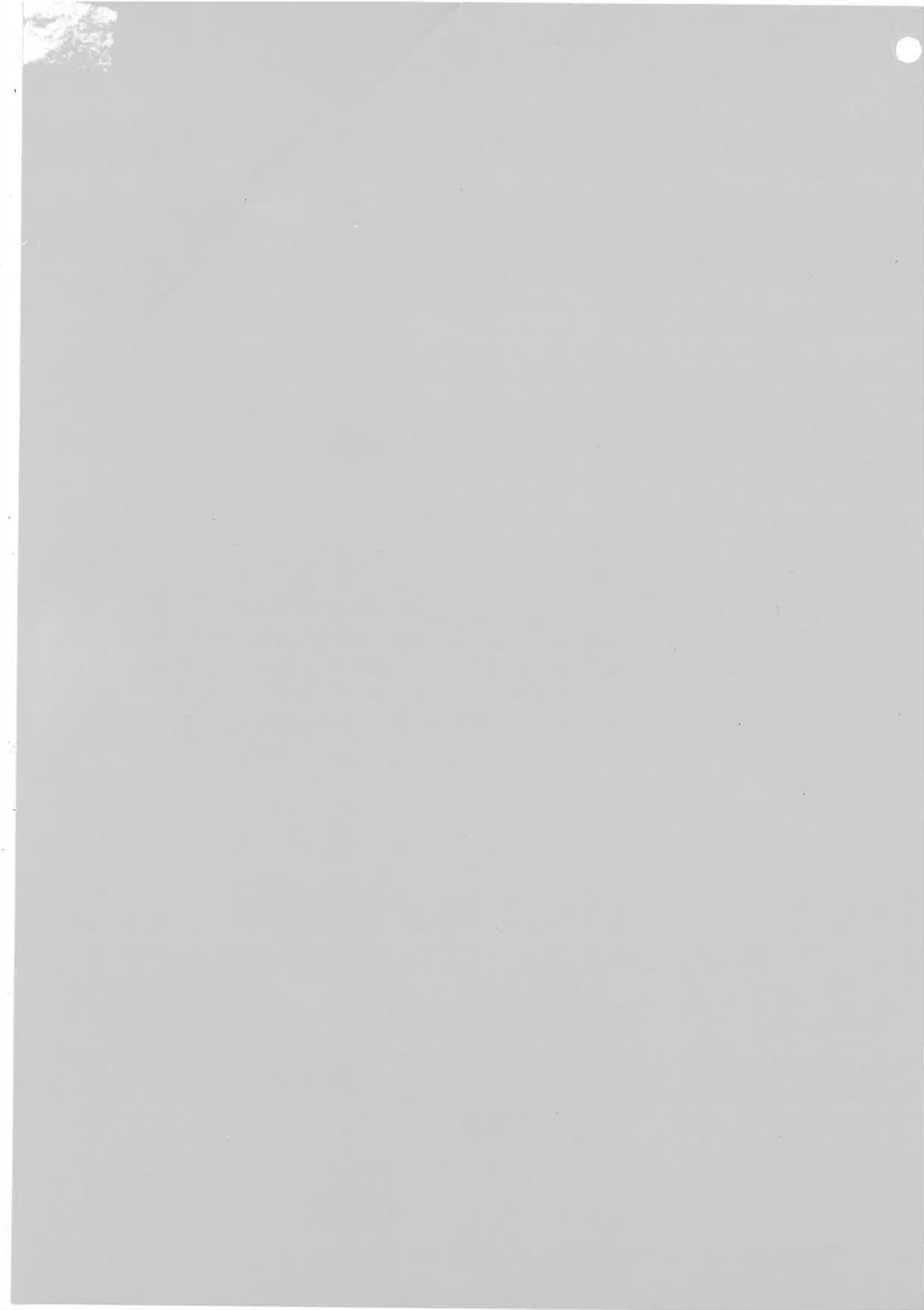
Complete, fold and seal
(see note 2 below)

SURNAME: Llhwicrap

FORENAME(S): Tiegen FERN

1	Student Number	P149406
2	Title of Examination Paper	ADVANCED VEHICLE DYNAMICS
3	Module Code	M6X00415
4	Date and Time of Examination	21-05-19 12pm
5	Examination Venue	IO 310
6	Seat Number	G053
7	Number of Answer Books handed in	

List the numbers of the questions you have attempted	Office Use
1	16
2	11
3	7
	~~34~~
Total	57



a) distance 'a' = $\frac{\text{rear mass}}{\text{Tot mass}} \times \text{wheelbase}$
 $= \% \times \text{wheelbase}$
 $= 0.58 \times 2718$
 $= 1576.44 \text{ mm} = 1.6 \text{ m}$

1/2

b) $C = \frac{I}{ma}$ where $I = 1300$

$$C = \frac{1300}{1170 \times 1.576} = 0.705 \text{ m}$$

carrying
entail.

2/2

c) $I = mk^2$

$$k^2 = \frac{I}{m} \therefore k = \sqrt{\frac{I}{M}}$$

$$\sqrt{111.1}$$

$$k = \sqrt{\frac{1300}{1170}} = 1.054 \text{ m}$$

2/2

d) $DI = \frac{I}{ma b}$

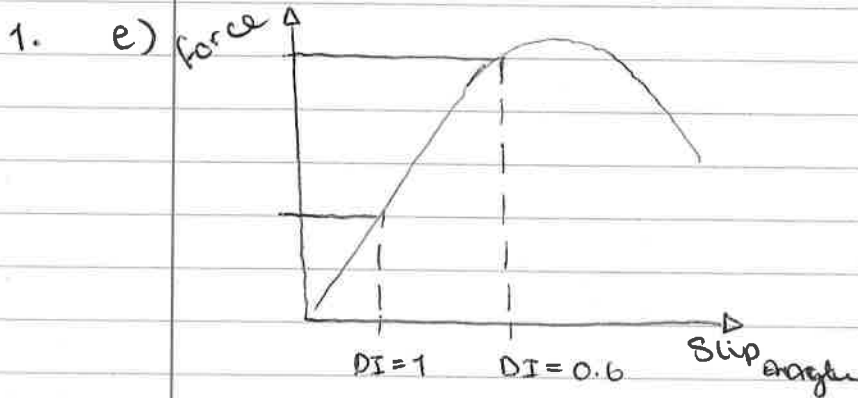
$$b = 0.42 \times 2718 = 1141.56 \text{ mm}$$

$$= 1.14156 \text{ m}$$

$$= \frac{1300}{1170 \times 1.576 \times 1.14} = 0.618$$

Typically cars with a DI of 1 are stable as centre of percussion is on rear axle. Values higher than this tend to be too stable and are difficult to 'turn-in', yet values under 1 tend to be more controllable and turn-in easier. However if the value is below 0.8 then the vehicle is too unstable and is difficult to manoeuvre about corners. As such for the touring car in question a DI value of 0.618 suggests it is unstable and handling is difficult as the car wants to spin too much.

1 1/2
2



If the DI is ~~greater~~ ^{lower} than 1 then as the car corners the rear wheels tend to move outwards. As such the tyres generate a slip angle, which increases the rear lateral grip. If a driver was to then adjust the angle of the steered wheel, more slip angle is produced and the available grip becomes saturated.

As such the vehicle becomes difficult to ~~turn in~~ control, as the rear lateral grip is much less so vehicle spins more.



If DI is ~~lower~~ ^{greater} than 1, then the rear tyres adjust inwards which helps to reduce the slip angle, without decreasing the lateral grip. This means the lateral grip increases until it meets the saturation limit and begins to decrease as such high DI 's make cars too stable and meaning they don't like to 'turn-in'.

1. f) The physiological limitations of drivers relate to the response between input and output. Drivers receive an input through senses (eyes, ears, touch) and this sends a message to the brain where there is a delay due to the brain processing information. This then relays to muscle movement and the driver makes the required changes. Due to this process there is a limitation due to delays between the driver receiving an input and the driver's response. These response times can further be affected by external factors such as being under the influence (drink/drugs), concentration, fatigue or distractions.

 $\frac{1\frac{1}{2}}{2}$

g) Part 1:

$$DI = \frac{I}{ma} = \frac{mk^2}{mab} = \frac{k^2}{ab}$$

• As ~~operates~~ drive is symmetric a and b remain unchanged.

$$k^2 = DIab$$

$$k = \sqrt{DIab}$$

$$k = \sqrt{0.87 \times 1.57 \times 1.14} = 1.25 \text{ m}$$

Part 2: I increase by $1850 - 1300 = 550 \text{ kg}\cdot\text{mm}$

$$c = \frac{I}{ma}$$

$$I = mk^2$$

$$m = \frac{I}{k^2}$$

$$I = cma$$

$$m = \frac{I}{k^2} = \frac{550}{(1.05+3) \times (1.57+3)} = 29.72 \text{ kg}$$

 $\frac{3}{3}$
 $\frac{2}{3}$
 $\frac{16}{20}$

Q2. a) centri accel = $\frac{vel^2}{rad} = \frac{13.8^2}{25} = 7.72 \text{ m/s}^2$

50 kph = 50000 mph $\rightarrow 13.8 \text{ m/s}^2$

b) circumference = $2\pi r = 157.08 \text{ m}$

$157.08 / 13.8 = 11.31 \text{ sec/lap}$

yaw rate = $360 / 11.31 = 31.83 \text{ deg/sec}$

c) Static weight = $\left(\frac{1500}{2}\right) \times 9.81 = 7357.5 \text{ N per axle}$

Static per wheel = 3678.75 N

WT = $0.6 \times \frac{\text{mass}}{2} \times \frac{\text{accel}}{\text{track}}$

$= 0.6 \times 750 \times \frac{7.72}{1.5} = 2316 \text{ N Axle}$ Wheel = 1158

Outer wheels = $3678.75 + 2316 = 5994.75 \text{ N}$ $1158 \times 2 = 4836.75$

Inner wheels = $3678.75 - 2316 = 1362.75 \text{ N}$ $1158 \times 2 = 2316$

d) $F = ma$

Vertical force on each axle = $750 \times 9.81 = 7357.5 \text{ N}$

Each wheel = 3678.75

Outer load percentage = $\frac{5994.75}{3678.75} = 1.6$
 $= \frac{3678.75}{5994.75} = 0.614 = 61.4\%$

Inner load percentage = $3678.75 / 1362.75 =$

$$d) RR = G \times \text{mass} \times \text{Coefficient of RR}$$

$$= 9.81 \times 1500 \times 0.013$$

$$= 191.295 \text{ N}$$

$$\text{Aero} = 0.5 \times A \times C_d \times 1.2 \times \text{vel}^2$$

$$= 0.5 \times 3 \times 0.5 \times 1.2 \times 13.8^2$$

$$= 171.396$$

$$\text{Tractive effort} = 362.691$$

Drive force on each wheel =

$$\text{outer wheels} = 5994.75 - 362.691 = 5632.059 \text{ N}$$

$$\text{inner wheels} = 1362.75 - 362.691 = 1000.059 \text{ N}$$

$$e) F = ma \quad \text{Lateral force} = 750 \times 7.72$$

$$= 5790 \text{ N}$$

$$f) \text{ vert force on axle} = 750 \times 9.81 = 7357.5 \text{ N}$$

$$\text{on each wheel} = 3678.75 \text{ N}$$

vert

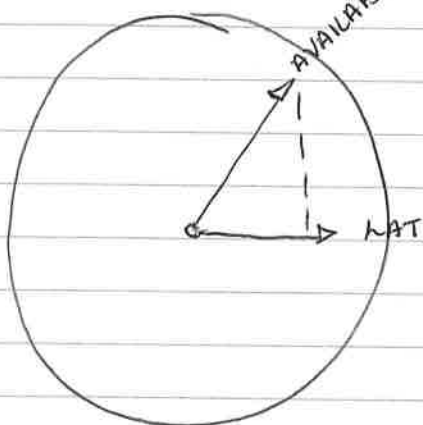
$$\text{Outer load \%} = 3678.75 / 4836.75 = 0.76$$

$$\text{Inner load \%} = 3678.75 / 2520.75 =$$

g) over

g)

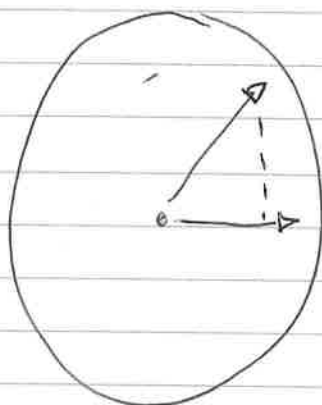
OUTER.



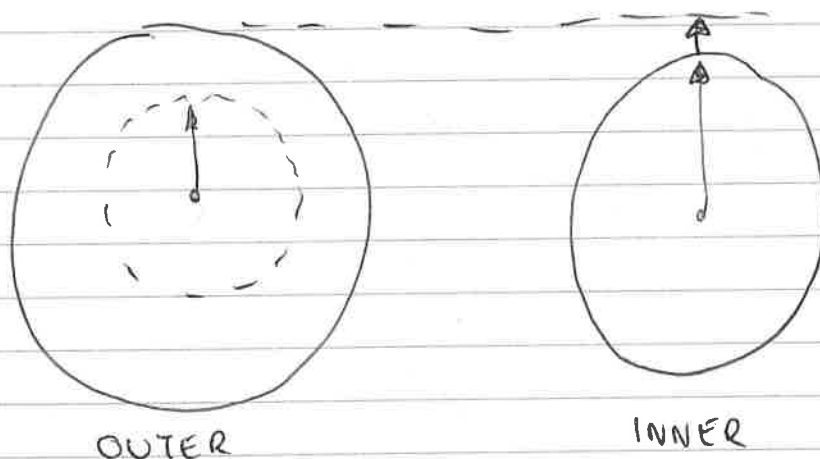
$$\text{Available grip} = 3678 \times 1 = 3678.$$

$$\text{LONG} = \sqrt{\text{AVAILABLE}^2 - \text{LAT}^2}$$

INNER



h)



By torque vectoring torque is added via the brakes so that the system becomes symmetric.

As such.

Torque left = torque right.

Torque left = $T_{\text{brake}} + T_{\text{grip}}$

Torque left = $T_B + T_{\text{grip}}$

* TURN PAGE FOR Question 3.

Question No.

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rit y Cwestiwn

33.

a) $50 \text{ kph} = 13.8 \text{ m/s}^2$

Vertical force on each wheel = 3678.75 N ✓

low grip side = $3678.75 \times 0.05 = 183.9375 \text{ N}$

as no ABS, vehicle is limited by low μ side.

so

$F = ma \quad F = 183.94$

$a = \frac{183.94}{1500} = 0.12 \text{ m/s}$

b) yaw moment = FL

F is symmetrical = $183.94 \times$

yaw moment = $183.94 \times \frac{1.5}{2} = 137.96$

c) rot accel = $\frac{I}{\text{moment}} = \frac{2200}{137.96} = 15.94 \text{ deg/sec}$

d) $F = ma$.

~~Lateral force =~~

Vertical force = $750 \times 9.81 = 7357.5 \text{ N}$

each wheel = 3678.75 N

low $\mu = 183.9375$

high $\mu = 3678.75 \times 0.7 = 2575.125 \text{ N}$

tot available grip = 2759.0625 N

e)

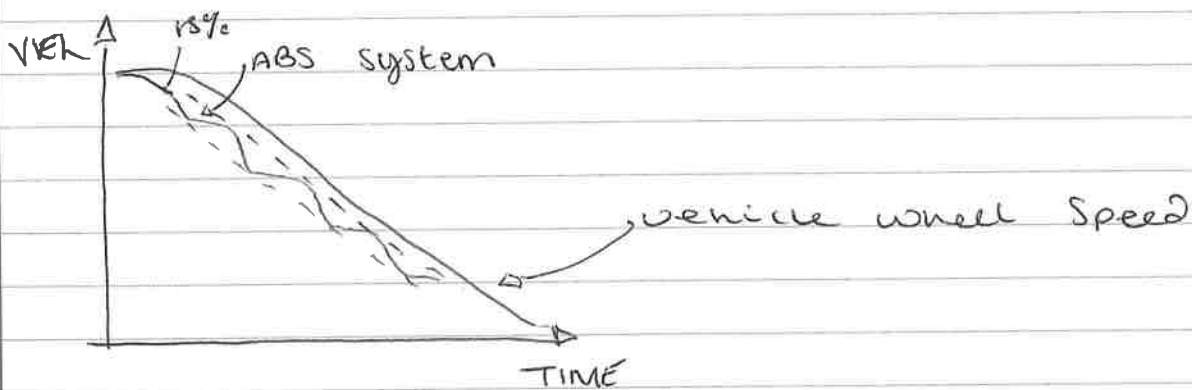
9/2

f)

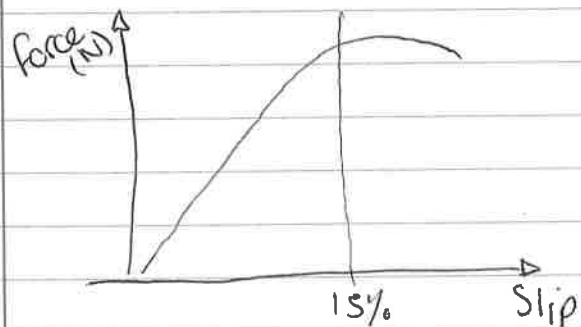
0/3

- g) An abs System would use wheel speed sensors to monitor the speed and apply the brakes to reduce the speed by 15%. It uses a PID System which utilises progressive, integrators and ~~der~~ derivatives methods to determine the outcomes. The graph shows that there is the vehicle velocity. The Abs is then initialised to reduce the velocity by 15%. The ABS will then lift off before applying again. This process allows Abs to ~~mon~~ monitor the brake line pressures and adjust according it also allows for the 'select low wear' System to work so that the rear tyres still have an amount of lateral grip.

3.6.



3/6



7/20

Question No.

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