

12 Pages

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 accept a legible 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.**

1	Student Number	1805164
2	Title of Examination Paper	Advanced vehicle dynamics
3	Module Code	MBX00415
4	Date and Time of Examination	21/05/19 12:00
5	Examination Venue	310
6	Seat Number	G049
7	Number of Answer Books handed in	

List the numbers of the questions you have attempted	Office Use
1	16 1/2
2	17 1/2
3	17
	51
Total	85

(Gweler yr ochr arall am y fersiwn Cymraeg)

Complete, fold and seal
(see note 2 below)

SURNAME: Zhao Cong

FORENAME(S): sun



Q1

a) $\therefore$ 58% front, 42% rear, $\therefore$ CG is close to front axle

$$\therefore a = 0.42 \times 2718 = 1141.56 \text{ mm}$$

 $2/2$

b)
$$c = \frac{I}{m a} = \frac{1300}{1170 \times 1141.56} = 973.37 \text{ mm}$$

 $2/2$

c) $\therefore I = m k^2$

$$\therefore k = \sqrt{\frac{I}{m}} = \sqrt{\frac{1300}{1170}} = 1.054 \text{ m} = 1054 \text{ mm}$$

 $2/2$

d)
$$DI = \frac{I}{mab} = \frac{1300 \times 10^6}{1170 \times 1141.56 \times (2718 - 1141.56)} = 0.61742$$

$DI = 0$ center of percussion is on rear axle
 $DI > 1$: a very stable vehicle ~~that~~ that is reluctant to turn in

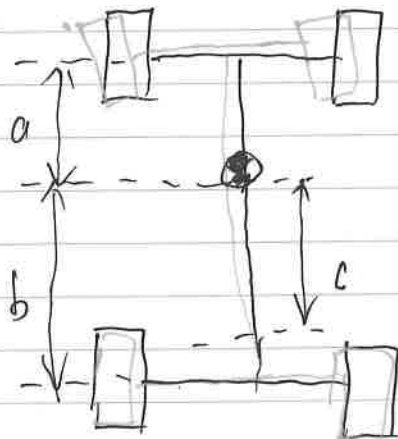
 $2/2$

$DI < 1$: stable vehicle that turn in ok

$DI < 0.8$: is unstable, turn in too quickly and is hard to control

e)

diagram :



- 1) When $DI < 1$, when the vehicle turn in, the rear wheel will move outer to build slip angle and generate lateral grip
- 2) ~~the~~ Around corner, any additional steering angle application will result in rear wheel moving outer to ~~generate~~ have more slip angle
- 3) If rear wheels are limited, the lateral grip are limited, therefore, reduce lateral force.
- 4) If $DI < 0.6$, there will be lots of instability, the vehicle is hard to control.

(5)

ear: the signals ~~is~~ ~~passed~~ by transferred by tension ~~muscle~~ muscle, which will limit the response times

eyes: However, the signals need about 300 ms for the driver to take some action.

(9)

1.

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

$$\therefore k = \sqrt{ab \cdot DI} = \sqrt{1141.56 \times (6718 - 1141.56) \times 0.87} = 1251.26 \text{ mm}$$

2.

$$\text{extra inertia} = 1850 - 1300 = 550 \text{ kg m}^2$$

$$\text{distance} = \frac{\text{wheelbase}}{2} = \frac{2718}{2} = 1359 \text{ mm}$$

$$I = md^2 + md^2$$

$$\therefore m = \frac{I}{2d^2} = \frac{550}{2 \times (1.359)^2} = 148.89 \text{ (kg)}$$

Q2

(a)

$$\text{total mass} = 750 + 750 = 1500 \text{ kg}$$

$$50 \text{ km/h} = \left(\frac{50}{3.6}\right) = 13.89 \text{ m/s}$$

$$\text{centripetal acce} = \frac{v^2}{R} = \frac{13.89^2}{25} = 7.71 \text{ (m/s}^2\text{)}$$

2/2

(b)

$$C = \pi d = 50\pi = 157.08 \text{ m}$$

$$t = \frac{C}{v} = \frac{157.08}{13.89} = 11.309 \text{ (s)}$$

2/2

$$\therefore \text{yaw rate} = \frac{360^\circ}{11.309} = 31.83 \text{ deg/second}$$

$$= 0.5556 \text{ rad/second}$$

(c)

$$\text{wheel mass} = (750 + 750) \times 9.8 / 4 = 3675 \text{ N}$$

$$\text{Weight transfer} = \frac{ma_{ch}}{2L} = \frac{1500 \times 7.71 \times 0.6}{2 \times 1.5} = 2313 \text{ (N)}$$

$$\text{inner wheel} = 3675 - 2313 = 1362 \text{ (N)}$$

$$\text{outer wheel} = 3675 + 2313 = 5988 \text{ (N)}$$

2/2

d) rolling resistance = $mg\mu_r = 1500 \times 9.8 \times 0.013 = 191.1 \text{ (N)}$
 air dynamic force = $\frac{1}{2} C_D A \rho v^2 = \frac{1}{2} \times 0.5 \times 3 \times 1.2 \times 13.89^2 = 173.6 \text{ N}$

$\therefore$ drive force = $191.1 + 173.6 = 364.7 \text{ (N)}$

2/12

(e) $F = ma = 750 \times 7.71 = 5782.5 \text{ (N)}$
 $\uparrow$

Lateral force = mass $\times$ acc.

1/1

(f) vertical force of each axle = $mg = 750 \times 9.8 = 7350 \text{ N}$

inner vertical % = $1362 / 7350 = 0.185$

outer vertical % = 0.815

Therefore

inner

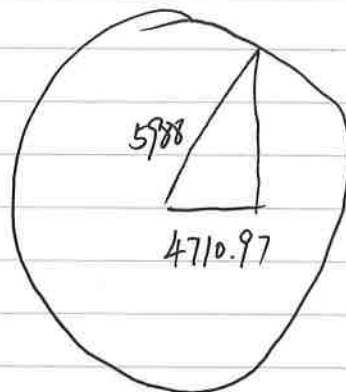
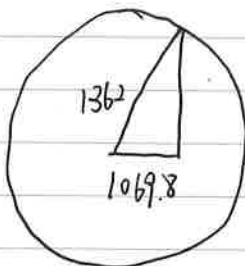
inside ~~lateral~~ lateral force = $5782.5 \times 0.185 = 1069.7625 \text{ N}$

outside lateral force = $5782.5 \times 0.815 = 4710.97 \text{ (N)}$

3/3

(g) $\therefore$ friction is 1.0

$\therefore$



inner rear wheel

Long force = $\sqrt{1362^2 - 1069.8^2}$
 $= 842.95 \text{ (N)}$

outer rear wheel

Long force = $\sqrt{5788^2 - 4710.97^2}$
 $= 3696.34 \text{ (N)}$

Because there are open differential

Some drive force are used to overcome resistance

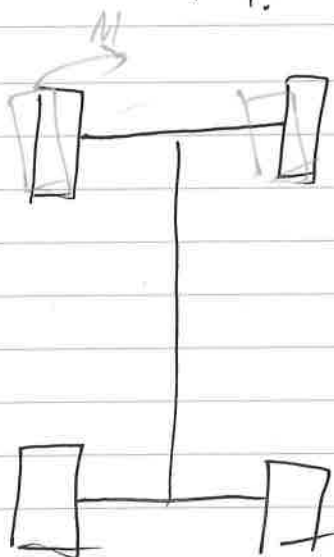
$$\therefore \text{drive force} = 842.95 \times 2 - 334.7 = 1321.2 \text{ (N)}$$

additional

(h)

According to the calculations and directions above, there will exist yaw moment when the vehicle enter a corner.

The torque vectoring differential would change the slip angle and generate more lateral force. Therefore ~~more~~ the yaw moment could be overcome.



17 1/2
20

Q3

the mass of left and right is both 750 kg

(a) low u side : $f = \mu mg = 750 \times 9.81 \times 0.05 = 367.875 \text{ (N)}$ ✓

high u side : $f = \mu mg = 750 \times 9.81 \times 0.7 = 5150.25 \text{ (N)}$ ✓

deceleration = $\frac{F}{m} = \frac{367.875 + 5150.25}{1500} = \frac{5518.125}{1500} = 3.67875 \text{ (m/s}^2\text{)}$
0.49

(b) $\Delta \text{ force} = 5150.25 - 367.875 = 4782.375 \text{ (N)}$

$\therefore \text{ jam moment} = F s = 4782.375 \times \frac{1.5}{2} = 3686.78 \text{ (N}\cdot\text{m)}$

(c) $\tau = I \alpha \therefore \alpha = \frac{\tau}{I} = \frac{3686.78}{2200} = 1.63 \text{ rad/s}^2$

(d) $\therefore \text{ front} = 750 \text{ kg rear} = 750 \text{ kg}$

$\therefore \text{ CoG to the front axle} = 0.5 \times 2.65 = 1.325$ ✓

$\therefore \text{ force} = \frac{\text{moment}}{\text{distance}} = \frac{3686.78}{1.325} = 2782.48 \text{ (N)}$

(e) $\text{degree} = \frac{\text{force}}{1000 \text{ N/deg}} = 2.78 \text{ degrees}$

$\therefore \text{ ratio} < 15 = 1$

$\therefore \text{ required hand wheel ang} = 15 \times 2.78 = 41.73 \text{ degrees}$

(f) now is equipped with ABS

low u side : $F_f = \mu mg = 750 \times 9.81 \times 0.1 = 735.75 \text{ (N)}$

high u side : $F_f = \mu mg = 750 \times 9.81 \times 0.9 = 6621.75 \text{ (N)}$

deceleration = $\frac{F}{m} = \frac{735.75 + 6621.75}{1500} = 4.905 \text{ (m/s}^2\text{)}$

(9) 1) Firstly, some sensors should be installed, For, example

4 Wheel speed sensors.

3-axle g sensors

yaw rate sensor

steering angle sensor

brake pedal sensor



2) how it works.

According to the wheel speed of each wheel and lateral acceleration, the ~~turning~~ radius of curve could be calculated.

Then, we could calculate the difference between wheel speed and vehicle speed. If vehicle speed is 15% faster than wheel speed, the brake must be released more pressure.

~~With the~~ Then, the velocity is reduced. The system will calculate the difference between wheel speed and vehicle. If the difference is smaller, then the system could add the brake pressure again.

Therefore, the vehicle could achieve controllable vehicle deceleration.

4/6

17/20

Question No.

Examiner Only

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