



**Complete, fold and seal**  
(see note 2 below)

SURNAME: Harries

FORENAME(S): Stuart

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 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.**

|   |                                  |                                            |
|---|----------------------------------|--------------------------------------------|
| 1 | Student Number                   | P150227                                    |
| 2 | Title of Examination Paper       | Vehicle Dynamics                           |
| 3 | Module Code                      | MSX00407                                   |
| 4 | Date and Time of Examination     | 11/01/19                                   |
| 5 | Examination Venue                | AS222<br>Swinsea<br><del>Burn</del> Campus |
| 6 | Seat Number                      |                                            |
| 7 | Number of Answer Books handed in | 1                                          |

[illegible]

(Gweler yr ochr arall am y fersiwn Cymraeg)



Q1)

$$a) (1500)(9.81)(1.2) = 17658 \text{ N}$$

$$\text{Mass} = 1500 \text{ kg}$$

$$\mu = 1.2$$

$$\text{Rolling Radius} = 0.32 \text{ m}$$

$$17658 \times 0.32 = 5650.56 \text{ Nm}$$

$$\text{Torque} = 5650.56 \text{ Nm}$$

2/2

$$b) \text{ Outer radius} = 50 \text{ mm} = 0.05 \text{ m}$$

$$\text{Inner radius} = 47.5 \text{ mm} = 0.0475 \text{ m}$$

$$\text{Cone angle } \alpha = 7^\circ$$

$$\text{Steel on steel } \mu = 0.2$$

$$T = 3000 \text{ Nm}$$

$$T = \frac{F \cdot \mu (r_o + r_i)}{2 \sin \alpha}$$

rearrange for (F)

$$(T)(2 \sin \alpha) = F \mu (r_o + r_i)$$

$$\frac{(T)(2 \sin \alpha)}{(\mu)(r_o + r_i)} = F$$

$$\frac{(3000)(2 \sin 7)}{(0.2)(0.05 + 0.0475)} = \frac{731.22}{0.0195}$$

$$F = 37498 \text{ N}$$

Question 1b is at the end of the booklet

c) We are assuming that the clutch is new ~~so~~ so has not got any wear

$\frac{1}{2}$   
3

d) Flywheel

$$\begin{aligned} KE &= 1 \text{ MJoule} \\ \omega &= 10000 \times \frac{2\pi}{60} \\ \omega &= 1047.2 \text{ rad/s/sec} \\ \text{Outer } r &= 0.5 \text{ m} \end{aligned}$$

Mass of Flywheel ?

$$I = mk^2$$

$$m = ?$$

$$KE = \frac{1}{2} I \omega^2$$

$$1 \times 10^6 = \frac{1}{2} I (1047.2)^2$$

$$(1 \times 10^6)(2) = I (1047.2)^2$$

$$\frac{(1 \times 10^6)(2)}{(1047.2)^2} = I$$

$$I = 1.82 \text{ kg m}^2$$

$$I = m k^2$$

$$k = \text{outer radius} \times 0.707 = 0.25 \times 0.707$$

$$k = 0.177 \text{ m}$$

$$\frac{I}{k^2} = m \quad \frac{(1.82)}{(0.177)^2} = m$$

$$\frac{4}{4}$$

$$m = 58.1 \text{ kg}$$

e) Flywheel mass = Area x Density x Thickness

$$\frac{\text{Mass}}{\text{Area} \times \text{Density}} = \text{Thickness}$$

$$\text{Density of steel} = \frac{\text{Mass}}{\text{Volume}} = 7820 \text{ kg m}^{-3}$$

$$\frac{58.1}{\pi (0.25^2) (7820)} = \text{Thickness}$$

$$= 0.038 \text{ m}$$

$$\frac{3}{3}$$

$$\text{Flywheel mass} = 58.1 \text{ kg}$$

$$\text{Flywheel thickness} = 0.038 \text{ m}$$

$$\frac{9}{2}$$

\* Redone at the end of the booklet as was given Density

$$\frac{14 \frac{1}{2}}{20}$$

Q2)  $C_D = 0.7$

Density of Air  $= 1.2 \text{ kg/m}^3$

$R_R = 0.005 \text{ N}$

Vel  $= 40 \text{ kph}$

$a = 1 \text{ m/s}^2$

Unladen weight  $= 5500 \text{ kg}$

$20 \times 100 \text{ kg} = 2000 \text{ kg}$

a)  $F = ma$

$F = (7500)(9.81)(1)$   
 $F = 73575 \text{ N}$

$a = 1 \text{ m/s}^2$

$m = \cancel{5500} 5500 + 2000$

$m = 7500 \text{ kg}$

b) Distance covered  $= 40 \times \frac{1000}{3600} = 11.111 \text{ m/s}$

11

Q2G)  $P = 1.2 \times 10^6 \text{ J}$   
 $\omega = 4000 \times \frac{2\pi}{60}$   $\Delta \omega = 418.88 \text{ rad/sec}$

$$P = T \omega$$

$$\frac{P}{\omega} = T$$

$$\frac{1.2 \times 10^6}{418.88} = T$$

$$T = 2864.78 \text{ Nm}$$

$$\frac{1\frac{1}{2}}{5}$$

$$\frac{4}{20}$$

Question No.

Examiner Q

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Q3)

a) Force acting on the rear axle? Front axle mass = 900 kg

Rear axle mass = 900 kg

Track width = 1.5 m

Wheelbase = 2.8 m

Tyre rolling radius = 0.35 m

C of G = 0.7 m

 $M_u \text{ left} = 1$  $M_u \text{ Right} = 0.1$ 

9/4

$$F = (900)(9.81)\left(\frac{0.1}{1}\right)$$

$$F = 882.9 \text{ N}$$

b)  $F = ma$ 

$$T_L = T_R$$

$$T_R = (900)(9.81)(0.1)$$

$$= 882.9 \text{ N}$$

$$\frac{F}{m} = a$$

$$\frac{882.9}{900} = 0.4905 \text{ m/s}^2$$

$$\frac{882.9}{1800} = 0.4905 \text{ m/s}^2$$

2/4

$$c) 882.9 \times 3 = 2648.7 \text{ N}$$

$$\frac{F}{m} = a$$

$$\frac{2648.7}{1800} = 1.4715 \text{ m/s}^2$$

1 1/2 / 3

d) ~~use~~ use all available grip

$$(900)(9.81)(1) = 8829 \text{ N} + 882.9 \text{ N}$$

$$= 9711.9 \text{ N}$$

$$F = ma$$

$$\frac{F}{m} = a$$

$$\frac{9711.9}{1800} = 5.39 \text{ m/s}^2$$

\* None as even drive torque on each wheels

e) 10 kph

2/5

9/4

5/20

Q1e) given Density of Steel as  $7700 \text{ kg/m}^3$

Flywheel mass = Area  $\times$  Density  $\times$  thickness

$$\frac{\text{Flywheel mass}}{\text{Area} \times \text{Density}} = \text{thickness}$$

$$\frac{58.1}{(\pi \cdot 0.25^2)(7700)} = 0.038 \text{ m}$$

$$T = 3000 \text{ Nm}$$

Q1b)  $\phi$  outer = 100 mm  $\rightarrow$  radius = 50 mm = 0.05 m  
 $\phi$  inner = 95 mm  $\rightarrow$  radius = 47.5 mm = 0.0475 m

Cone angle  $\alpha = 7^\circ$

$$\mu = 0.2$$

$$T = \frac{1}{\sin \alpha} \cdot \frac{2}{3} \mu \cdot F \cdot \frac{(r_o^3 - r_i^3)}{(r_o^2 - r_i^2)}$$

$$(T)(\sin \alpha)(3)(r_o^2 - r_i^2) = (2)(\mu)(F)(r_o^3 - r_i^3)$$

$$\frac{(T)(\sin \alpha)(3)(r_o^2 - r_i^2)}{(2)(\mu)(r_o^3 - r_i^3)} = F$$

$$F = \frac{(3000)(\sin 7)(3)(0.05^2 - 0.0475^2)}{(2)(0.2)(0.05^3 - 0.0475^3)}$$

$$F = \frac{0.026}{7.13 \times 10^{-6}}$$

$$F = 3646.56 \text{ N}$$

Clamp force

5/6

Q2)

a) Force required

$$RR = (0.005N)(9.81)(7500 \text{ kg}) = \cancel{37} 367.88 \text{ N}$$

~~Area~~ =

$$\text{Area} = 13 \text{ m}^2$$

$$\text{Aero Resistance} = (0.5)(13)(1.2)(0.7)(11.11^2) \\ = 674.06 \text{ N}$$

$$\text{Total Force} = 674.06 + 367.88 \\ = 1041.94 \text{ N}$$

$$\text{Total Power} = 11576.95 \text{ Watts}$$

$$\text{b) Distance covered} = \underline{1041.94}$$