



SWANSEA METROPOLITAN UNIVERSITY

PRIFYSGOL FETROPOLITAN ABERTAWE

Faculty of Applied Design and Engineering

School of Automotive Engineering

HND Motorsport/ Automotive/ Motorcycle Engineering

Year 1

Engineering Science

Test 1

Monday 3rd February 2013

11 am

Instructions to candidates:

There are three questions in this paper, answer all questions.

Give all answers to 2.d.p.

Name:.....*Solutions*.....

1.



A Jaguar XC75 car has a mass of 1350kg. The car can accelerate uniformly from rest up to 100km/h in 3.4 seconds, from 100km/h to 160km/h in 2.1 seconds and finally from 160km/h to 300km/h in 10.2 seconds. Draw a velocity time graph [4 marks] and calculate:

- The acceleration up to 100km/h. [5 marks]
- The total distance covered. [18 marks]
- The maximum kinetic energy of the DS3. [3 marks]

The XC75 micro turbine motor develops 1600Nm of torque and generates the equivalent of 140kW of power.

- the angular velocity of the turbine.

[4 marks]

Given that the rotating parts of the turbine can be accelerated from rest to this speed in 3.4 seconds, and that they have a radius of gyration of 0.25m calculate

- the mass of the rotating parts.
- The rotary energy of the system.

[12 marks]

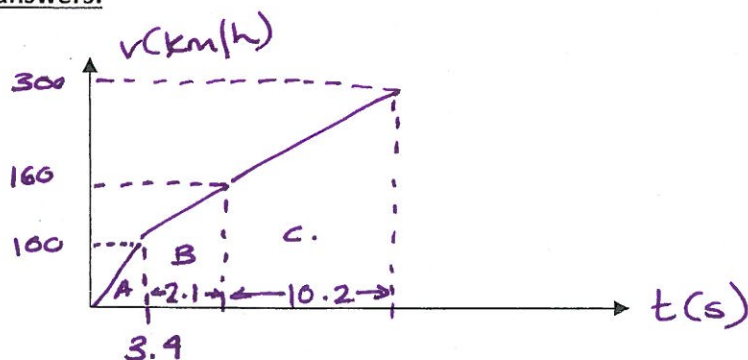
[4 marks]

[12 marks]

[3 marks]

$$KE = \frac{1}{2}mv^2 \quad P = T\omega \quad T = I\alpha \quad I = mk^2 \quad KE = \frac{1}{2}I\omega^2$$

Space for answers:



a) $u = 0$

$$v = 100 \text{ km/h} \times \frac{1000}{3600} = 27.78 \text{ m/s}$$

$$t = 3.4 \text{ s}$$

$$a = ?$$

$$v = u + at$$

$$a = \frac{v-u}{t} = \frac{27.78}{3.4} = 8.17 \text{ m/s}^2 \text{ (2.d.p.)}$$

b) Looking @ 'A'

$$u = 0$$

$$s = \frac{1}{2} \times \text{base} \times \text{height} = \frac{1}{2} \times 3.4 \times 27.78$$

$$v = 27.78 \text{ m/s}$$

$$t = 3.4 \text{ s}$$

$$s = ?$$

$$s = 47.25 \text{ m (2.d.p.)}$$

Looking @ 'B'

$$u = 27.78 \text{ m/s}$$

$$s = \frac{(u+v)t}{2}$$

$$v = 160 \times \frac{1000}{3600} = 44.44 \text{ m/s}$$

$$t = 2.1 \text{ s}$$

$$s = ?$$

$$s = \frac{(44.44 + 27.78) \times 2.1}{2}$$

$$s = 75.83 \text{ m (2.d.p.)}$$

Looking @ 'C'

$$u = 44.44 \text{ m/s}$$

$$s = \frac{(u+v)t}{2}$$

$$v = 300 \times \frac{1000}{3600} = 83.33 \text{ m/s}$$

$$t = 10.2 \text{ s}$$

$$s = ?$$

$$s = \frac{(44.44 + 83.33) \times 10.2}{2}$$

$$s = 651.627 \text{ m} = 651.63 \text{ m (2.d.p.)}$$

$$\therefore \text{Total distance travelled} = 47.25 + 75.83 + 651.63 = 774.69 \text{ m}$$

$$\text{c) } KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 1350 \times 83.33^2 = 4687125.00 \text{ J} = 4.69 \text{ MJ}$$

$$\text{d) } T = 1600 \text{ Nm}$$

$$P = T\omega$$

$$P = 140 \text{ kW}$$

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

$$= 140000 \text{ W}$$

$$= \frac{140000}{1600}$$

$$= 87.5 \text{ rad/s}$$

$$e) \omega_1 = 0$$

$$\omega_2 = 87.5 \text{ rad/s}$$

$$t = 3.4 \text{ s}$$

$$\alpha = ?$$

$$\omega_2 = \omega_1 + \alpha t$$

$$\alpha = \frac{\omega_2 - \omega_1}{t} = \frac{87.5}{3.4} = 25.74 \text{ rad/s}^2 \quad (2 \text{ dp})$$

$$I = I \alpha$$

$$I = \frac{I}{\alpha} = \frac{1600}{25.74} = 62.16 \text{ kg m}^2$$

$$I = m k^2$$

$$m = \frac{I}{k^2} = \frac{62.16}{0.25^2} = 994.56 \text{ kg}$$

$$f) KE = \frac{1}{2} I \omega^2 = \frac{1}{2} \times 62.16 \times 87.5^2 = 237956.25 \text{ J} \\ = 237.96 \text{ kJ.}$$

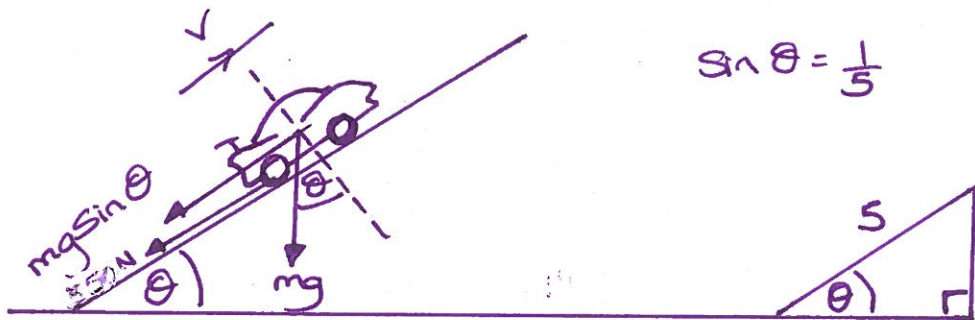
2.

a. The Jaguar of mass 1350kg and power 580kW is driven on a level road at its maximum velocity of 300km/h, calculate the coefficient of friction between the road and car tyres. [7 marks]

b. The car is now driven up Constitution Hill at a constant speed, given that the hill is inclined at 1 in 5 measured along the slope, and that the frictional force between the tyres and the road is 550N, construct a basic forces diagram [3 marks] and calculate the velocity. [13 marks]

$$P = Fv$$

$$F = \mu R = \mu mg$$



a) $m = 1350 \text{ kg}$

$$v = 300 \text{ km/h} \times \frac{1000}{3600} = 83.33 \text{ m/s}$$

$$P = 580 \text{ kW} = 580000 \text{ W}$$

$$\mu = ?$$

$$P = Fv$$

$$P = \mu mgv$$

$$F = \mu mg$$

$$\mu = \frac{P}{mgv} = \frac{580000}{(1350 \times 9.81 \times 83.33)} = 0.53 \text{ (no units)}$$

b) Forces acting downhill:

$$= 550 + mg \sin \theta$$

$$= 550 + (1350 \times 9.81 \times \frac{1}{5})$$

$$= 3198.7 \text{ N}$$

$$P = Fv$$

$$\therefore v = \frac{P}{F} = \frac{580000}{3198.7} = 181.32 \text{ m/s}$$

3. An internal combustion engine's valve train is accelerated from rest to 6500rpm in 0.05s, given that a single valve has a mass of 25g, calculate:

a. The angular acceleration the valve experiences, [5 marks]

b. The number of revolutions turned through in this time. [5 marks]

Given that once the valve had reached its operating speed of 6500rpm it can be considered to move with simple harmonic motion with amplitude of 25mm, calculate:

c. The frequency of motion, [3 marks]

d. The periodic time of motion, [3 marks]

e. The maximum force experienced by the valve. [5 marks]

f. The displacement from the equilibrium position given the linear velocity at this point is 13.6m/s. [7 marks]

$$n = \frac{\omega}{2\pi} \quad T = \frac{2\pi}{\omega} \quad F_{\max} = m\omega^2 A \quad v = \omega\sqrt{A^2 - x^2} \quad F = m\omega^2 x$$

a) $\omega_1 = 0$

$$\omega_2 = 6500 \text{ rpm} \times \frac{2\pi}{60} = 680.68 \text{ rad/s.}$$

$$t = 0.05 \text{ s}$$

$$\alpha = ?$$

$$\omega_2 = \omega_1 + \alpha t \quad \therefore \alpha = \frac{\omega_2 - \omega_1}{t} = \frac{680.68}{0.05} = 13613.6 \text{ rad/s}^2$$

b) $\theta = ?$

$$\theta = \frac{(\omega_2 + \omega_1)t}{2} = \frac{(680.68 + 0)0.05}{2} = 17.02 \text{ radians.}$$

$$\therefore \theta = \frac{17.02}{2\pi} = 2.71 \text{ revolutions}$$

c) $N = \frac{\omega}{2\pi} = \frac{680.68}{2\pi} = 108.33 \text{ Hz.}$

d) $T = \frac{2\pi}{\omega} = \frac{2\pi}{680.68} = 9.2 \times 10^{-3} \text{ s}$
or 0.0092 s.

e) $F_{\max} = m\omega^2 A = 0.025 \times 680.68^2 \times 0.025$

$$F_{\max} = 289.58 \text{ N}$$

f) $v = 13.6 \text{ m/s}$.

$$v = \omega \sqrt{A^2 - x^2}$$

$$\frac{v}{\omega} = \sqrt{A^2 - x^2}$$

$$\left(\frac{v}{\omega}\right)^2 = A^2 - x^2$$

$$\left(\frac{v}{\omega}\right)^2 - A^2 = -x^2$$

$$x^2 = A^2 - \left(\frac{v}{\omega}\right)^2$$

$$x = \sqrt{A^2 - \left(\frac{v}{\omega}\right)^2}$$

$$x = \sqrt{0.025^2 - \left(\frac{13.6}{680.68}\right)^2} = 0.015 \text{ m}$$