



SWANSEA METROPOLITAN UNIVERSITY

PRIFYSGOL FETROPOLITAN ABERTAWE

Faculty of Applied Design and Engineering

School of Automotive Engineering

BEng Motorsport/ Automotive/ Motorcycle/Mechanical & Manufacturing Engineering

Year 1

Engineering Science

Test 1

Wednesday 29th January 2013

11 am

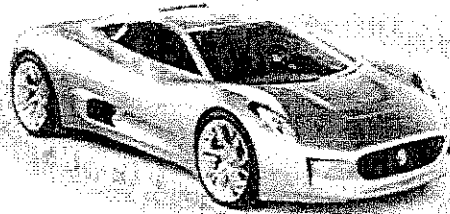
Instructions to candidates:

There are four 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]

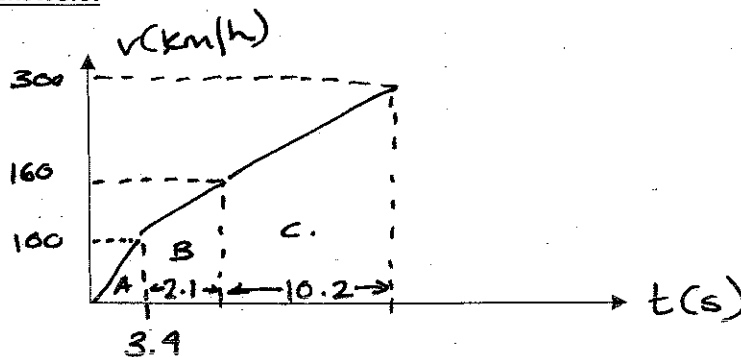
[4 marks]

[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'

$u = 0$

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

$t = 3.4 \text{ s}$

$s = ?$

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

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

Looking @ 'B'

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

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

$t = 2.1 \text{ s}$

$s = ?$

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

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

$s = 75.83 \text{ m (2dp)}$

Looking @ 'C'

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

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

$t = 10.2 \text{ s}$

$s = ?$

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

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

$s = 651.62 \text{ m} = 651.63 \text{ m (2dp)}$

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

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

d) $T = 1600 \text{ Nm}$
 $P = 140 \text{ kW}$
 $= 140000 \text{ W}$

$P = T\omega$

$\omega = \frac{P}{T} = \frac{140000}{1600} = 87.5 \text{ rad/s}$

e) $\omega_1 = 0$

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

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

$$\alpha = ?$$

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

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

$$T = I\alpha$$

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

$$I = mk^2$$

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

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

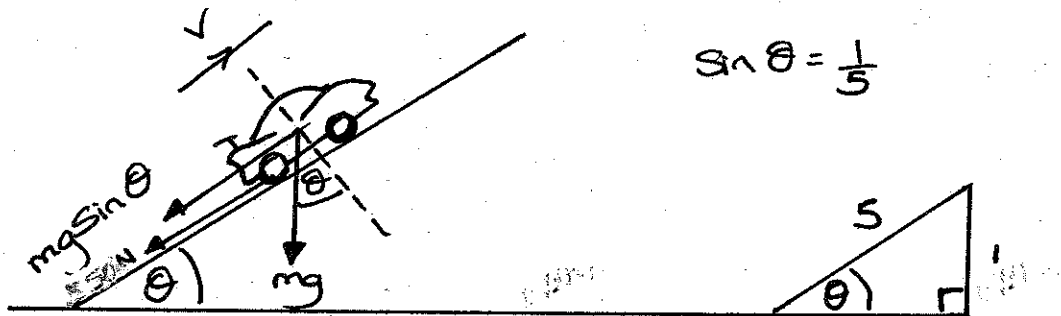
2.

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) $m = 1350 \text{ kg}$
 $v = 300 \text{ km/h} \times \frac{1000}{3600} = 83.33 \text{ m/s}$
 $P = 580 \text{ kW} = 580000 \text{ W}$
 $\mu = ?$

$$\begin{aligned} P &= Fv \\ P &= \mu mgv \end{aligned}$$

$$F = \mu mg$$

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

b) Forces acting downhill:
 $= 550 + mg \sin \theta$
 $= 550 + (1350 \times 9.81 \times \frac{1}{5})$
 $= 3198.7 \text{ N}$

$$\begin{aligned} P &= Fv \\ \therefore v &= \frac{P}{F} = \frac{580000}{3198.7} = 181.32 \text{ m/s} \end{aligned}$$

3. Gases in a single cylinder engine occupy a volume of $35 \times 10^{-5} \text{ m}^3$ at a pressure of $15 \times 10^5 \text{ Pa}$ immediately after combustion. Following expansion the new pressure is $1.8 \times 10^5 \text{ Pa}$, given that the temperature is kept at a constant throughout the process, calculate the volume at the end of expansion. Given that the bore of the cylinder is 0.12 m calculate the engine stroke. [13 marks]

$$V_1 = 35 \times 10^{-5} \text{ m}^3$$

$$V_2 = ?$$

$$P_2 = 1.8 \times 10^5 \text{ Pa}$$

$$P_1 = 15 \times 10^5 \text{ Pa}$$

$$T = \text{Constant}$$

Boyle's Law

$$P_1 V_1 = P_2 V_2$$

$$V_2 = \frac{P_1 V_1}{P_2} = \frac{15 \times 10^5 \times 35 \times 10^{-5}}{1.8 \times 10^5} = 2.92 \times 10^{-3} \text{ m}^3$$

$$\begin{aligned} \text{Volume of cylinder} &= V_2 - V_1 \\ &= 2.92 \times 10^{-3} - 35 \times 10^{-5} \\ &= 2.57 \times 10^{-3} \text{ m}^3 \end{aligned}$$

$$\therefore \text{Volume of cylinder, } V = \frac{\pi d^2 \times l}{4}$$

$$l = \frac{V}{\left(\frac{\pi d^2}{4}\right)} = \frac{2.57 \times 10^{-3}}{\left(\frac{\pi \times 0.12^2}{4}\right)} = \underline{\underline{0.23 \text{ m}}}$$

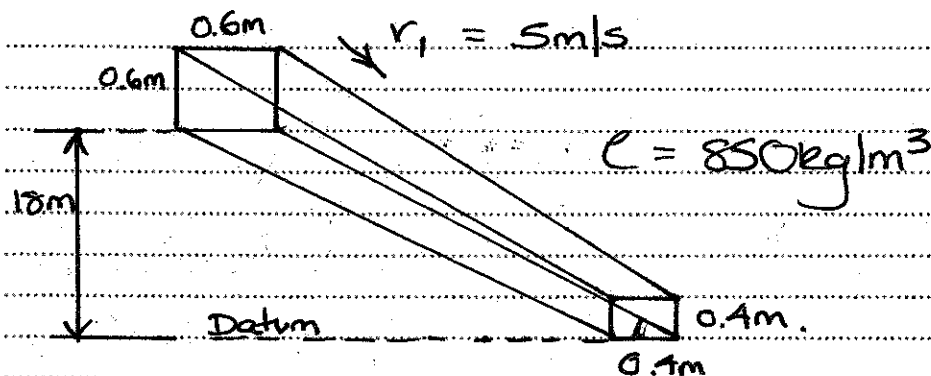
4. A square section of pipe has the cross sectional dimensions $0.6 \times 0.6\text{m}$ and carries fluid of density 850kg/m^3 at a velocity of 5m/s . At another section of pipe the cross section 18m lower the cross section dimensions have reduced to $0.4 \times 0.4\text{m}$. Calculate

a. the velocity at the lower end of the pipe. [6 marks]

b. the difference in pressure between the two sections of pipe. [6 marks]

c. the quantity of flow. [4 marks]

$$A_1 v_1 = A_2 v_2 \quad gh_1 + \frac{p_1}{\rho} + \frac{v_1^2}{2} = gh_2 + \frac{p_2}{\rho} + \frac{v_2^2}{2} \quad Q = Av$$



a) By Continuity:

$$A_1 v_1 = A_2 v_2$$

$$(l_1 \times l_1) v_1 = (l_2 \times l_2) v_2$$

$$v_2 = \frac{(l_1 \times l_1) v_1}{(l_2 \times l_2)}$$

$$v_2 = \frac{(0.6 \times 0.6) 5}{(0.4 \times 0.4)} = 11.25\text{m/s}$$

b) By Bernoulli's

$$gh_1 + \frac{p_1}{\rho} + \frac{v_1^2}{2} = gh_2 + \frac{p_2}{\rho} + \frac{v_2^2}{2}$$

$$gh_1 + \frac{v_1^2}{2} - \frac{v_2^2}{2} = \frac{p_2 - p_1}{\rho}$$

$$\rho \left[gh_1 + \frac{v_1^2}{2} - \frac{v_2^2}{2} \right] = p_2 - p_1$$

$$850 \left[(9.81 \times 18) + \left(\frac{5^2}{2} \right) - \left(\frac{11.25^2}{2} \right) \right] = p_2 - p_1$$

$$p_2 - p_1 = 106928.94\text{Pa} = 106.93\text{KPa (2dp)}$$

c) $Q = Av$
 $Q = (0.6 \times 0.6) 5$
 $Q = 1.8 \text{ m}^3/\text{s}.$