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EXAMINATIONS 2015 / 2016

ARHOLIADAU 2015 / 2016

FACULTY OF: Architecture, Computing & Engineering

NAME OF COURSE/PROGRAMME: BEng Engineering Programmes

YEAR OR LEVEL: Level 4

NAME OF MODULE/UNIT/EXAM PAPER: Engineering Science 1

MODULE NO: M1X8801 & M4X00385

DATE OF EXAMINATION:

EXAMINATION TIMES:

START TIME:

FINISH TIME:

TIME ALLOWED: 2 hours

INSTRUCTIONS TO CANDIDATES:

Answer **all** questions.

$g = 9.81\text{m/s}^2$

Give answers to 2.d.p.

You are allowed a scientific calculator and a dictionary.

1. A Ducati Panigale motorcycle, can accelerate up to 96.6km/h in 2.7 seconds, it can then reaches 215.4km/h after a further 7.7 seconds. It can be brought back to rest in 36m. Sketch a velocity-time graph [5 marks] and calculate:

- The rate of acceleration to 96.6km/h, [5 marks]
- The rate of acceleration from 96.6-215.4km/h, [4 marks]
- The total combined distance travelled for acceleration and deceleration. [8 marks]
- The total time taken for both movements. [6 marks]

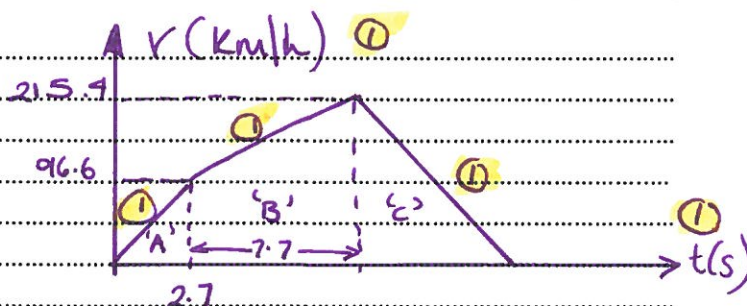
a) Looking @ 'A':

$$u = 0$$

$$v = 96.6 \times \frac{1000}{3600} = 26.83 \text{ m/s}$$

$$t = 2.7 \text{ s}$$

$$a = ?$$



$$v = u + at$$

$$a = \frac{v-u}{t}$$

$$a = \frac{26.83}{2.7} = 9.94 \text{ m/s}^2$$

b) Looking @ 'B':

$$u = 26.83 \text{ m/s}$$

$$v = 215.4 \times \frac{1000}{3600} = 59.83 \text{ m/s}$$

$$t = 7.7 \text{ s}$$

$$a = ?$$

$$a = \frac{v-u}{t} = \frac{59.83}{7.7}$$

$$a = 7.74 \text{ m/s}^2$$

c) Looking @ 'A':

$$u = 0$$

$$v = 26.83 \text{ m/s}$$

$$t = 2.7 \text{ s}$$

$$s = ?$$

$$s = \frac{1}{2} b \times h = \frac{1}{2} \times 2.7 \times 26.83$$

$$s = 36.22 \text{ m}$$

Looking @ B

$$u = 26.83 \text{ m/s}$$

$$v = 59.83 \text{ m/s}$$

$$t = 7.7 \text{ s}$$

$$s = ?$$

$$s = \frac{(u+v)t}{2} = \frac{(26.83+59.83)7.7}{2}$$

$$s = 333.64 \text{ m}$$

$$\therefore \text{Total distance} = 36.22 + 333.64 + 36 = 405.86 \text{ m}$$

d) Looking @ 'C':

$$u = 59.83 \text{ m/s}$$

$$v = 0$$

$$s = 36 \text{ m}$$

$$t = ?$$

$$s = \frac{(u+v)t}{2} \quad t = \frac{2s}{(v+u)} = \frac{2 \times 36}{59.83}$$

$$t = 1.2 \text{ s}$$

$$\therefore \text{Total time} = 2.7 + 7.7 + 1.2 = 11.6 \text{ sec}$$

2.

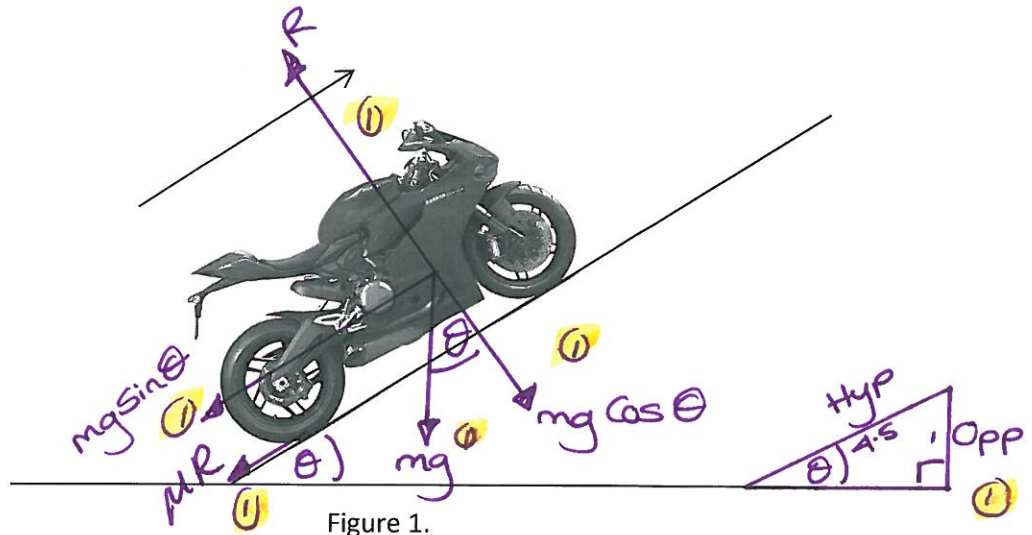


Figure 1.

Figure 1 above shows the Ducati Panigale driving up an incline measuring 1 in 4.5 measured along the slope. There the coefficient of friction between the tyres and the road surface of 0.35 and the mass of the Panigale is 193kg. Given that the power developed by the engine is 109kW, construct a forces diagram [4 marks] calculate the velocity of the Panigale. [3 marks]

5

$$P = F \cdot v$$

$$F = \mu R_n$$

14

$$m = 193 \text{ kg}$$

$$P = 109 \times 10^3 \text{ W}$$

$$\mu = 0.35$$

$$\sin \theta = \frac{\text{Opp}}{\text{Hyp}} = \frac{1}{4.5}$$

$$\theta = \sin^{-1} \left(\frac{1}{4.5} \right)$$

Forces acting down slope:

$$\theta = 12.84^\circ$$

$$F = mg \sin \theta + \mu R$$

$$F = mg \sin \theta + \mu mg \cos \theta$$

$$F = (193 \times 9.81 \times \frac{1}{4.5}) + (0.35 \times 9.81 \times \cos 12.84)$$

$$F = 1066.81 \text{ N}$$

$$P = F \cdot v$$

$$v = \frac{P}{F} = \frac{109000}{1066.81} = 102.17 \text{ m/s}$$

3.

The Ducati Panigale develops its maximum Torque of 99Nm at 9000rpm, given that the engine can achieve this speed in 0.95s, and that the rotating parts of the engine can be assumed to have a radius of gyration of 280mm, calculate:

- The mass of the rotating components, [12 marks]
- The power developed by the engine at the speed. [2 marks]
- The torque developed at 10750rpm which is when the Panigale achieves its maximum power of 109kW. [5 marks]

$$P = T\omega \quad T = I\alpha \quad I = mk^2 \quad k^2 = \frac{d^2}{8}$$

$$T = 99 \text{ Nm}$$

$$\omega_2 = 9000 \times \frac{2\pi}{60} = 942.48 \text{ rad/s}$$

$$k = 0.28 \text{ m}$$

$$t = 0.95 \text{ s}$$

$$a) \omega_1 = 0$$

$$t = 0.95 \text{ s}$$

$$\alpha =$$

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

$$\alpha = \frac{\omega_2 - \omega_1}{t}$$

$$\alpha = \frac{942.48}{0.95} = 992.08 \text{ rad/s}^2$$

$$T = I\alpha$$

$$I = \frac{T}{\alpha} = \frac{99}{992.08} = 0.099 \text{ kgm}^2$$

$$I = mk^2$$

$$m = \frac{I}{k^2} = \frac{0.099}{0.28^2} = 0.28 \text{ kg}$$

$$b) P = T\omega = 99 \times 942.48 = 93305.52 \text{ W}$$

$$c) \omega = 10750 \times \frac{2\pi}{60} = 1125.74 \text{ rad/s}$$

$$P = 109 \times 10^3 \text{ W}$$

$$P = T\omega \quad T = \frac{P}{\omega} = \frac{109 \times 10^3}{1125.74} = 96.83 \text{ Nm}$$

4.

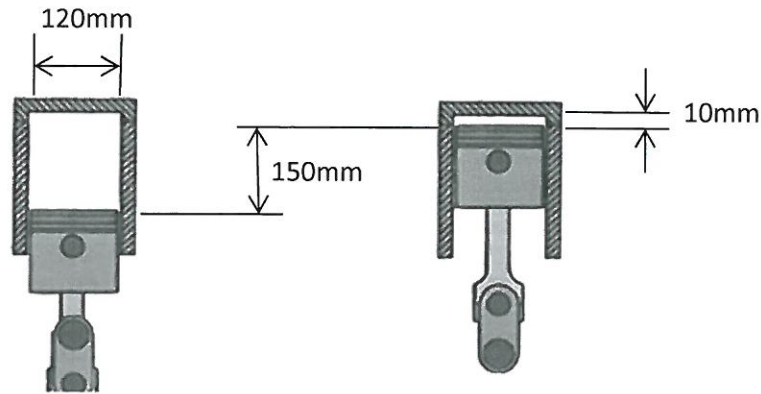


Figure 2

The large single cylinder engine has dimensions of those shown in Figure 2. At the commencement of the compression stroke the pressure is 1.2bar. Given that the pressure has increased to 32bar at a temperature of 287°C, calculate:

a. The compression ratio,

[11 marks]

b. The temperature before combustion.

[6 marks]

$$a) V_1 = \frac{\pi d^2 \times l}{4} = \frac{\pi \times 0.12^2 \times 0.15}{4} = 1.696 \times 10^{-3} \text{ m}^3$$

$$V_2 = \frac{\pi d^2 \times l}{4} = \frac{\pi \times 0.12^2 \times 0.01}{4} = 1.13 \times 10^{-4} \text{ m}^3$$

$$r = \frac{V_1}{V_2} = \frac{1.696 \times 10^{-3}}{1.13 \times 10^{-4}} = 15:1$$

$$b) \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$T_1 = \frac{P_1 V_1 T_2}{P_2 V_2} = \frac{(1.2 \times 10^5 \times 15 \times 560)}{(32 \times 10^5 \times 1)} = 315 \text{ K}$$

5.

Beer, of density 1000 kg/m^3 , flows from a barrel, similar to that in figure 3, via a horizontal tap. The diameter of the tap at the entrance is 40mm and the velocity of the beer entering the tap is 0.75m/s. Given that the exit pressure is 1.013bar and the diameter of the tap is 20mm, calculate the pressure inside the barrel. [11 marks]



Figure 3

$$d_1^2 v_1 = d_2^2 v_2$$

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

THIS QUESTION HAS A MULTIPLE CHOICE ANSWER, CIRCLE ONE ONLY:

a. 105518.75bar

b. 1.06bar

c. 105.51bar

d. 10.5.5bar

By Continuity: $d_1^2 v_1 = d_2^2 v_2$

$$v_2 = \frac{d_1^2 v_1}{d_2^2} = \frac{0.04^2 \times 0.75}{0.02^2} = 3 \text{ m/s}$$

By Bernoulli's:

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

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

$$p_1 = 1000 \left[\left(\frac{1.013 \times 10^5}{1000} \right) + \left(\frac{3^2}{2} \right) - \left(\frac{0.75^2}{2} \right) \right]$$

$$p_1 = 105518.7 \text{ N/m}^2$$

$$= 1.0551 \text{ bar}$$

6.

A composite silicon hose as shown in figure 4, comprises of an inner and outer layer of silicon of thermal conductivity 191 W/Mk and thickness 1.5mm, and a middle layer of nylon weave with a thermal conductivity of 5W/mK and thickness 3.5mm. The hose runs through an engine bay, has an outer diameter of 40mm and is 70mm long. Given that the fluid within the hose is of a temperature of 80°C and the engine bay temperature is 38°C, Calculate the heat transfer. [15 marks]

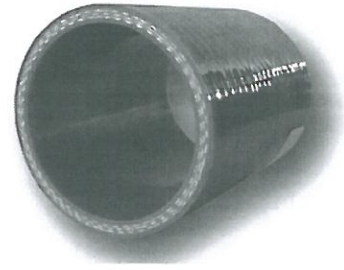


Figure 5.

$$\frac{1}{U} = \frac{1}{U_a} + \frac{1}{U_b} + \frac{1}{U_c}$$

$$Q = -UA(T_1 - T_2)$$

THIS QUESTION HAS A MULTIPLE CHOICE ANSWER, CIRCLE ONE ONLY:

a. 521.93kW

b. 521.93W

c. 51.6.2kW

d. 516.2W

$$U_a = U_c = \frac{k}{x} = \frac{191}{1.5 \times 10^{-3}}$$

$$U_b = \frac{k}{x} = \frac{5}{3.5 \times 10^{-3}}$$

$$\frac{1}{U} = \frac{1}{U_a} + \frac{1}{U_b} + \frac{1}{U_c}$$

$$\frac{1}{U} = \frac{1.5 \times 10^{-3}}{191} + \frac{3.5 \times 10^{-3}}{5} + \frac{1.5 \times 10^{-3}}{191}$$

$$\frac{1}{U} = 7.16 \times 10^{-4} \quad \therefore U = \frac{1}{7.16 \times 10^{-4}} = 1397.22 \text{ W/m}^2\text{K}$$

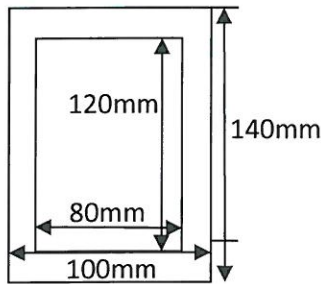
$$Q = -UA(T_1 - T_2)$$

$$Q = -1397.22 (\pi d \times l) (T_1 - T_2)$$

$$Q = -1397.22 (\pi \times 0.04 \times 0.07) (38 - 80)$$

$$Q = \underline{\underline{516.2 \text{ W}}}$$

7.



A section of chassis in a vehicle can be modelled as box section with dimensions as seen in the diagram left. The beam experiences a bending moment of 4000Nm. Given that the material of the chassis has a Young's modulus of elasticity of 205GN/m², calculate the maximum stress and the radius of curvature of the beam.

[15 marks]

$$I = \frac{BD^3}{12} - \frac{bd^3}{12}$$

$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$$

$$B = 0.1\text{m} \quad b = 0.08\text{m} \quad M = 4000\text{Nm}$$

$$D = 0.14\text{m} \quad d = 0.12\text{m} \quad E = 205 \times 10^9 \text{N/m}^2$$

$$y = \frac{D}{2} = \frac{0.14}{2} = 0.07$$

$$I = \frac{BD^3}{12} - \frac{bd^3}{12} = \left[\frac{0.1 \times 0.14^3}{12} \right] - \left[\frac{0.08 \times 0.12^3}{12} \right]$$

$$I = 1.135 \times 10^{-5} \text{m}^4$$

$$\frac{M}{I} = \frac{\sigma}{y} \quad \therefore \sigma = \frac{My}{I} = \frac{4000 \times 0.07}{1.135 \times 10^{-5}} = 24.67 \text{MN/m}^2$$

$$\frac{M}{I} = \frac{E}{R} \quad \therefore R = \frac{EI}{M} = \frac{205 \times 10^9 \times 1.135 \times 10^{-5}}{4000} = 581.69 \text{m}$$

8.

A drive shaft has an annular cross section with an inner diameter of 50mm. It is to be subjected to a torque of ~~40~~ 40 Nm, given that the maximum shear stress must not exceed 52 MN/m², calculate the shaft inner diameter. *to 4dp.*

40 Nm

[14 marks]

3

$$J = \frac{\pi(D^4 - d^4)}{32}$$

$$\frac{T}{J} = \frac{\tau}{r} = \frac{G\theta}{l}$$

$$d = 0.05 \quad \textcircled{1}$$

$$T = 40 \text{ Nm}$$

$$\tau = 52 \times 10^6 \text{ N/m}^2 \quad \textcircled{2}$$

$$\frac{T}{J} = \frac{\tau}{r} \quad \textcircled{3}$$

$$T \cdot r = \tau \cdot J \quad \textcircled{4}$$

$$r = \frac{D}{2} \quad \textcircled{5}$$

$$T \cdot \frac{D}{2} = \tau \cdot \frac{\pi(D^4 - d^4)}{32} \quad \textcircled{6}$$

$$J = \frac{\pi(D^4 - d^4)}{32}$$

$$16T \cdot D = \tau \cdot \pi(D^4 - d^4) \quad \textcircled{7}$$

$$16T \cdot D = \tau \pi D^4 - \tau \pi d^4 \quad \textcircled{8}$$

$$\tau \pi d^4 = \tau \pi D^4 - 16T \cdot D \quad \textcircled{9}$$

$$d^4 = \frac{\tau \pi D^4 - 16T \cdot D}{\tau \pi} \quad \textcircled{10}$$

$$d = \sqrt[4]{\frac{(\tau \pi D^4 - 16TD)}{\tau \pi}} \quad \textcircled{11}$$

$$d = \sqrt[4]{\frac{(52 \times 10^6 \times \pi \times 0.05^4) - (16 \times 40 \times 0.05)}{(52 \times 10^6 \times \pi)}} \quad \textcircled{12}$$

$$d = 0.0496 \text{ m} \quad \textcircled{13}$$

