



SWANSEA METROPOLITAN UNIVERSITY

PRIFYSGOL FETROPOLITAN ABERTAWE

Faculty of Applied Design and Engineering

School of Automotive Engineering

Foundation Engineering

Year 0

Engineering Science

Phase Test

Friday 28th May 2011

Instructions to candidates:

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

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

Course (please circle): Motorsport/Automotive/ Motorcycle/ Manufacturing/ Lame Computer Stuff.

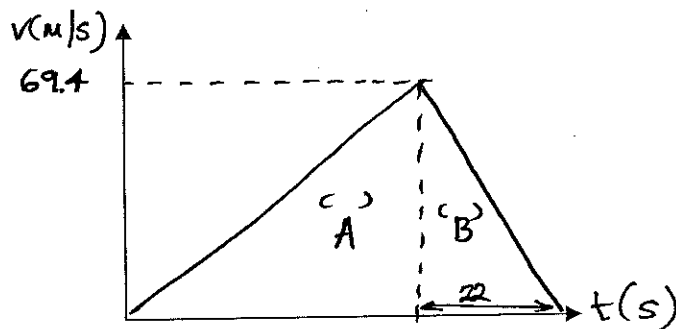
Question 1.

A drag car with a mass of 575kg is parked on the start line. From here it is accelerated uniformly for 350m during which time it has reached a maximum velocity of 250km/h. It is immediately brought to rest in 22 seconds, construct a velocity time diagram [3 marks] and calculate:

- | | |
|--|-----------|
| a) The uniform acceleration, | [5 marks] |
| b) The time taken to cover the first 350m, | [4 marks] |
| c) The uniform deceleration, | [5 marks] |
| d) The total distance travelled, | [5 marks] |
| e) The car's kinetic energy at its maximum velocity. | [3 marks] |

$$KE = \frac{1}{2}mv^2$$

Space for calculations:



$$m = 575 \text{ kg}$$

$$u = 0$$

$$v = 250 \text{ km/h} \times \frac{1000}{3600} = 69.4 \text{ m/s} \quad (1)$$

$$s = 350 \text{ m}$$

a) $a = ?$ Looking @ 'A':

$$v^2 = u^2 + 2as \quad (1)$$

$$\frac{v^2 - u^2}{2s} = \frac{2as}{2s} \quad (1)$$

$$a = \frac{v^2 - u^2}{2s} = \frac{69.4^2}{(2 \times 350)} = 6.89 \text{ m/s}^2 \quad (1)$$

b) $t = ?$ Looking @ 'A':

$$s = \frac{(u+v)t}{2} \quad (1)$$

$$\frac{2s}{(u+v)} = \frac{(u+v)t}{(u+v)} \quad (1)$$

$$t = \frac{2s}{(u+v)} = \frac{(2 \times 350)}{(0 + 69.4^2)} = 0.49 \text{ s} \quad (1)$$

c) Looking @ 'B'

$$u = 69.4 \text{ m/s}$$

$$t = 22 \text{ s}$$

$$v = 0$$

$$a = ?$$

$$v = u + at \text{ ①} \Rightarrow v - u = at$$

$$\frac{v - u}{t} = \frac{a \times t}{t} \text{ ②}$$

$$a = \frac{v - u}{t} = \frac{0 - 69.4}{22} = -3.155 \text{ m/s}^2 \text{ ③}$$

d) Looking @ 'B'

$$s = ?$$

$$s = \frac{(u + v)}{2} t = \frac{(69.4 + 0)}{2} 22 = 763.4 \text{ m}$$

$$\therefore \text{Total distance travelled} = 350 + 763.4 \text{ ④} \\ = 1113.4 \text{ m. ④}$$

$$e) \quad KE = \frac{1}{2} mv^2 = \frac{1}{2} \times 575 \times 69.4^2 \text{ ⑤}$$

$$KE = 1384703.5 \text{ ⑥} \\ = 1.38 \text{ MJ.}$$

Question 2.

A flywheel of mass 1.25kg and radius of gyration 0.015m is accelerated from rest up to a maximum angular velocity of 5500rpm in a period of 25 seconds, calculate:

- The angle the flywheel rotates through, [4 marks]
- The angular acceleration, [4 marks]
- The torque, [6 marks]
- The kinetic energy, [3 marks]
- The power absorbed in the acceleration period. [3 marks]

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

If the mass of the flywheel is reduced by 0.25kg but it still experiences the same angular acceleration, calculate the difference in kinetic energy between the two mass' of flywheel. [8 marks]

Space for answers:

$$m = 1.25 \text{ kg} \quad k = 0.015 \text{ m} \quad \omega_2 = 5500 \text{ rpm} \times \frac{2\pi}{60} = 575.96 \text{ rad/s} \quad \textcircled{1}$$

$$t = 25 \text{ s} \quad \omega_1 = 0$$

$$a) \theta = ? \quad \theta = \frac{(\omega_1 + \omega_2)}{2} t = \frac{(0 + 575.96)}{2} \times 25 \quad \textcircled{1}$$

$$\theta = 7199.5 \text{ radians} \quad \textcircled{1}$$

$$b) \alpha = ? \quad \omega_2 = \omega_1 + \alpha t \quad \textcircled{1}$$

$$\omega_2 - \omega_1 = \alpha t \quad \textcircled{1}$$

$$\frac{\omega_2 - \omega_1}{t} = \frac{\alpha t}{t} \quad \textcircled{1}$$

$$\alpha = \frac{\omega_2 - \omega_1}{t} = \frac{575.96 - 0}{25} = 23.04 \text{ rad/s}^2 \quad \textcircled{1}$$

$$c) \textcircled{1} \quad T = I \alpha \quad \textcircled{1} \quad I = m k^2 \quad \textcircled{1}$$

$$T = 281.25 \times 23.04 \quad \textcircled{1} \quad I = 1.25 \times 0.015^2 \quad \textcircled{1}$$

$$T = 6471.6 \text{ Nm} \quad I = 281.25 \text{ kgm}^2 \quad \textcircled{1}$$

$$d) \quad KE = \frac{1}{2} I \omega^2 = \frac{1}{2} \times 281.25 \times 575.96^2 \quad \textcircled{1}$$

$$KE = 46.6 \text{ MJ} \quad \textcircled{1}$$

$$e) P = T w^{\textcircled{1}} = 6471.6 \times 575.96^{\textcircled{1}} = 3.73 \text{ MN}^{\textcircled{1}}$$

Question 3.

A single cylinder diesel engine has a volume of 0.0085m^3 when at bottom dead centre and a volume of 0.0012m^3 at top dead centre. This engine then compresses an air fuel mixture with a gas constant of 286.9J/kgK , from an intake temperature and pressure of 28°C and 101300N/m^2 respectively to a new pressure of 150400N/m^2 . Calculate:

- The compression ratio, [3 marks]
- The mass of gas at the start of compression, [5 marks]
- The temperature after compression has taken place, [5 marks]
- The mass of gas at the end of compression. [4 marks]

$$PV = mRT \quad \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

Space for calculations:

$$\begin{aligned} V_1 &= 0.0085\text{m}^3 \\ T_1 &= (28+273)\text{K} \\ P_1 &= 101300\text{N/m}^2 \end{aligned}$$

$$\begin{aligned} V_2 &= 0.0012\text{m}^3 \quad R = 286.9\text{J/kgK} \\ T_2 &= ? \\ P_2 &= 150400\text{N/m}^2 \end{aligned}$$

$$a) \quad r = \frac{V_1}{V_2} = \frac{0.0085}{0.0012} = 7.083 : 1$$

$$b) \quad PV = mRT \quad \therefore m = \frac{PV}{RT}$$

$$\frac{PV}{RT} = \frac{mRT}{RT} \quad m = \frac{101300 \times 0.0085}{286.9 \times (28+273)}$$

$$m = 0.0098\text{kg} \quad \text{or} \quad 9.8 \times 10^{-3}\text{kg}$$

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

Cross multiply to get T_2 on the top.

$$\frac{P_1 V_1}{T_1} \rightarrow \frac{P_2 V_2}{T_2} \quad \therefore \frac{T_2}{T_1} = \frac{P_2 V_2}{P_1 V_1}$$

Multiply by T_1 both sides

$$\cancel{T_1} \times \frac{T_2}{\cancel{T_1}} = \frac{P_2 V_2}{P_1 V_1} \times T_1$$

$$T_2 = \frac{P_2 V_2 T_1}{P_1 V_1} = \frac{150400 \times 0.0012 \times (28+273)}{(101300 \times 0.0085)} \quad (1)$$

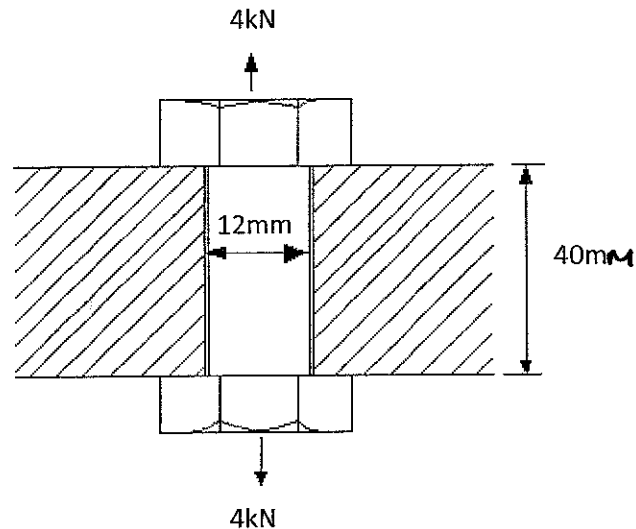
$$T_2 = \frac{\cancel{150400} \times \cancel{0.0012} \times 301}{101300 \times 0.0085} \quad (1)$$

$$1321.98 \text{ K} \quad (1)$$

d. $m = \frac{PV}{RT} = \frac{150400 \times 0.0012}{286.9 \times 1321.98} \quad (1)$

$$m = 0.00048 \text{ kg} \quad (1) \text{ or } 4.78 \times 10^{-4} \text{ kg}.$$

Question 4



Given that the load on the bolt in the figure above is 4kN and that Young's modulus, E is $200 \times 10^9 \text{ N/m}^2$, what is the stress on the bolt and how much does the bolt extend?

[20 marks]

Space for calculations:

$$F = 4 \times 10^3 \text{ N}$$

$$E = 200 \times 10^9 \text{ N/m}^2$$

$$\sigma = ?$$

$$x = ?$$

$$\text{Area of Bolt} = \frac{\pi d^2}{4}$$

$$= \pi \times (12 \times 10^{-3})^2$$

$$\sigma = \frac{F}{A} = \frac{4 \times 10^3}{1.13 \times 10^{-4}} = 35.37 \times 10^6 \text{ N/m}^2 = 1.13 \times 10^{-4} \text{ m}^2$$

$$= 35.37 \text{ MN/m}^2$$

$$E = \frac{\sigma}{\epsilon}$$

$$E = \frac{\sigma}{\epsilon}$$

$$\therefore \epsilon = \frac{\sigma}{E} = \frac{35.37 \times 10^6}{200 \times 10^9}$$

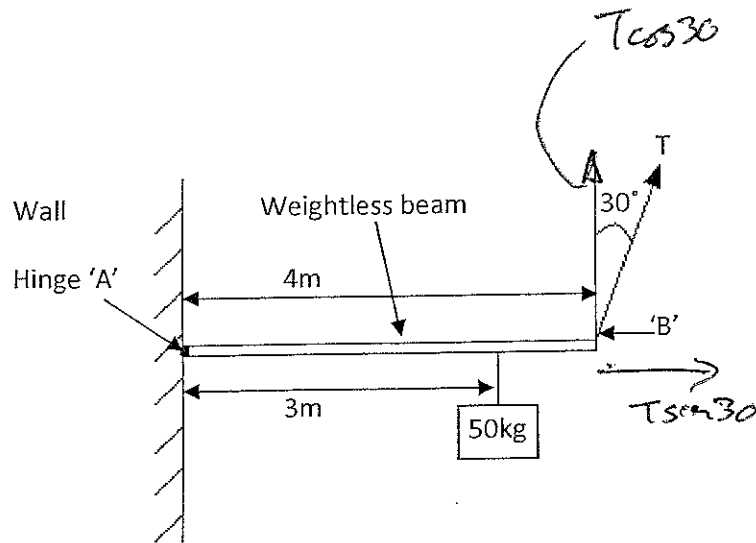
$$\epsilon = 1.77 \times 10^{-4}$$

$$x = \epsilon l$$

$$x = 1.77 \times 10^{-4} \times 0.04$$

$$x = 7.07 \times 10^{-6} \text{ m}$$

Question 5.



A weightless beam is hinged at 'A' and supported by a cable at 'B'. A weight is hung off the beam as shown. Find:

- The tension 'T', [10 marks]
- The horizontal and vertical forces at 'A', [10 marks]
- The magnitude and direction of the resultant force at 'A'. [10 marks]

Space for calculations:

a) Take Moments about Hing

$$50 \times 9 \times 3 = T \cos 30 \times 4$$

$$T = \frac{50 \times 9 \times 3}{\cos 30 \times 4} = \frac{1470}{3.464} = 424 \text{ N}$$

b) Horizontal Force $= T \sin 30 = 424 \times \frac{1}{2} = 212 \text{ N}$

Vertical Force $= 50 \times 9 - T \cos 30 = 450 - 367 = 123 \text{ N}$

c) Resultant Force $= \sqrt{123^2 + 212^2}$ (By Pythagoras)
 $= 245 \text{ N}$

Angle $= \tan^{-1} \frac{123}{212} = 30^\circ$

Question 6

Explain what the following terms mean:

- a) Ultimate tensile stress, [5 marks]
- b) Yield stress, [5 marks]
- c) 0.1% proof stress, [5 marks]
- d) Working stress, [5 marks]
- e) Creep. [5 marks]

Space for answer:

ULTIMATE TENSILE STRESS - The stress at which the material fails completely

YIELD STRESS The stress at which permanent deformation begins

0.1% proof stress - The stress that causes 0.1% permanent deformation when the load has been removed.

WORKING STRESS SOME ARBITRARY STRESS BELOW THE

YIELD STRESS OR PROOF STRESS THAT ~~BE~~ SHOULD NOT BE EXCEEDED. USUALLY BASED ON A SAFETY FACTOR APPLIED TO THE YIELD STRESS OR PROOF STRESS. THIS IS TO ALLOW FOR UNKNOWN FACTORS SUCH AS MATERIAL QUALITY, INACCURACY IN STRESS CALCULATIONS ETC.

CREEP - GRADUAL DEFORMATION UNDER STEADY LOAD THAT OCCURS MAINLY AT HIGH TEMPERATURES



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Friday 14th May 2010

Instructions to candidates:

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

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

Course:.....

Question 1.

The reciprocating components of an engine are considered to have a mass of 1.85kg and to move with Simple Harmonic Motion. When the piston is 50mm away from the centre of its oscillation it has a velocity of 38m/s, determine:

- a) The frequency of the oscillation, [7 marks]
- b) The stroke of the piston, [6 marks]
- c) The maximum velocity obtained by the piston, [3 marks]
- d) The maximum force acting on the body in kN. [4 marks]

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

Space for calculations:

Not in
Test.

Question 2.

A rotating shaft and flywheel have a total moment of inertia of 5kgm^2 and rotate at 3000rpm. If the frictional resistance of the engine is the equivalent to a torque of 2Nm and that value is constant over all speeds, find:

- The kinetic energy of the system and express it in kJ [6 marks],
- The power of the system [4 marks],
- The number of revolutions the engine will turn before it comes to rest when the fuel is cut [10 marks].

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

Space for answers:

$$I = 5\text{kgm}^2$$

$$\omega = 3000\text{rpm} \times \frac{2\pi}{60} = 314.16\text{ rad/s} \quad ①$$

$$T = 2\text{Nm}$$

$$a) \quad KE = \frac{1}{2} I \omega^2 = \frac{1}{2} \times 5 \times 314.16^2 = 242.67\text{kJ} \quad ②$$

$$b) \quad P = T \omega \quad ①$$

$$P = 2 \times 314.16 \quad ②$$

$$P = 628.32\text{W} \quad ③$$

$$c) \quad \omega_1 = 314.16\text{ rad/s}$$

$$\omega_2 = 0$$

$$\alpha = -0.4\text{ rad/s}^2$$

$$\theta = ?$$

$$T = I \alpha \quad ①$$

$$\alpha = \frac{T}{I} \quad ②$$

$$\omega_2^2 = \omega_1^2 + 2\alpha\theta \quad ③$$

$$\alpha = \frac{2}{5} \quad ④$$

$$\omega_2^2 - \omega_1^2 = 2\alpha\theta \quad ⑤$$

$$\alpha = 0.4\text{ rad/s}^2 \quad ⑥$$

$$\frac{\omega_2^2 - \omega_1^2}{2\alpha} = \frac{2\alpha\theta}{2\alpha} \quad ⑦$$

$$\text{Deceleration} = -0.4\text{ rad/s}^2$$

$$\theta = \frac{\omega_2^2 - \omega_1^2}{2\alpha} = \frac{0^2 - 314.16^2}{2 \times (-0.4)} = 123,370.6\text{ radians} \quad ⑧$$

$$\theta = \frac{123370.6}{2\pi} = 19,635\text{ revolutions} \quad ⑨$$

Question 3.

A quantity of air in a cylinder is compressed from 0.45m^3 to 0.025m^3 . The pressure is initially 200kN/m^2 and the temperature rises during the compression from 20°C to 122°C . What is the pressure of the compressed air? If the air is allowed to expand at constant temperature to its original volume, what will be the new pressure?

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

[10 marks]

Space for calculations:

$$\begin{aligned} V_1 &= 0.45\text{m}^3 & V_2 &= 0.025\text{m}^3 \\ P_1 &= 200 \times 10^3 \text{ N/m}^2 & P_2 &= ? \\ T_1 &= (20 + 273)\text{K} & T_2 &= (122 + 273)\text{K} \end{aligned}$$

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

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

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

$$P_2 = \frac{T_2 P_1 V_1}{V_2 T_1} = \frac{(122 + 273) \times 200 \times 10^3 \times 0.45}{0.025 \times (20 + 273)}$$

$$P_2 = \underline{4.85 \text{ MN/m}^2}$$

Constant Temp = Boyle's Law.

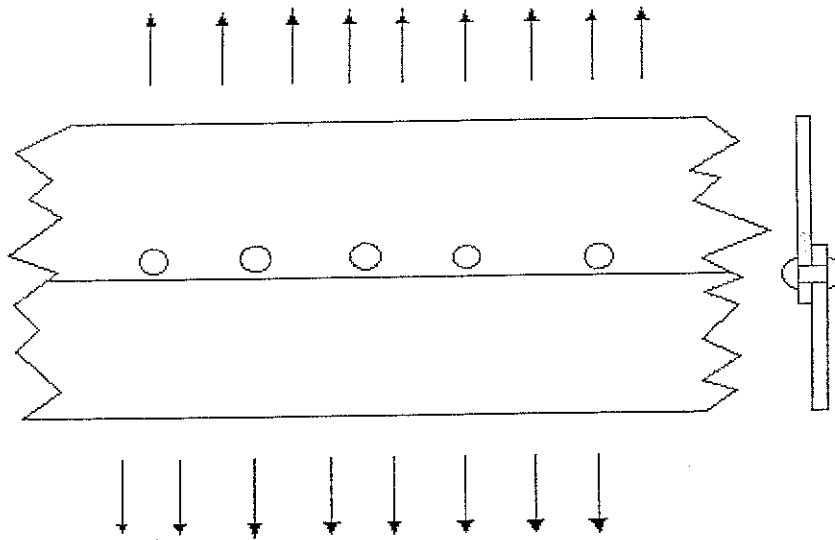
$$P_1 V_1 = P_2 V_2$$

$$P_2 = \frac{P_1 V_1}{V_2}$$

$$\begin{aligned} P &= 4.85 \times 10^6 \text{ N/m}^2 \\ V_1 &= 0.45\text{m}^3 \\ V_2 &= 0.025 \end{aligned}$$

$$P_2 = \frac{4.85 \times 10^6 \times 0.45}{0.025} = 269.6 \text{ kN/m}^2$$

Question 4



Two metal plates are joined together with a row of rivets. The two plates are subject to a force of 4kN for each meter of plate. If the minimum allowable shear stress on the rivet material is 100MN/m², what is the minimum number of rivets per meter required?

[10 marks]

$$G = \frac{\tau}{\gamma}$$

$$\tau = \frac{F}{A}$$

$$\gamma = \frac{\Delta l}{L}$$

Space for calculations:

Min ALLOWABLE STRESS ON RIVET MATERIAL = 100 MN/m²

$$\text{SHEAR STRESS } \tau = \frac{F}{A}$$

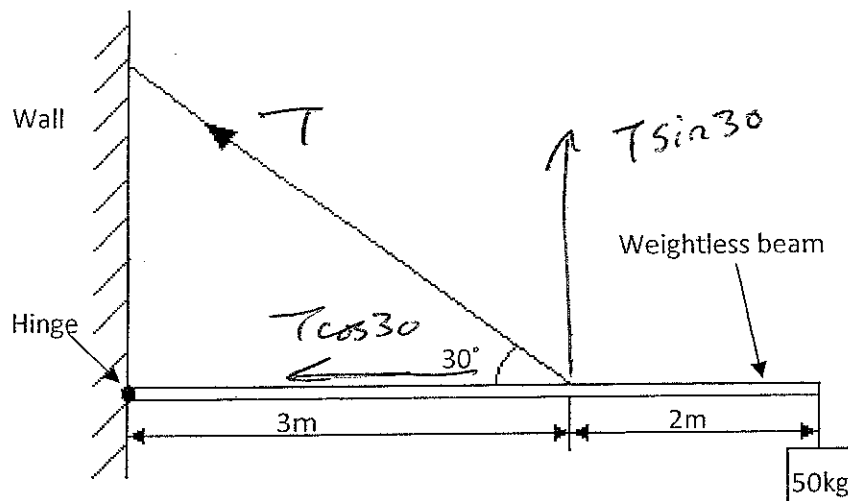
AREA OF ALL RIVETS MUST BE GREATER THAN $\frac{F}{\tau}$ per metre

$$A \geq \frac{4 \times 10^3}{100 \times 10^6}$$

$$\geq 4 \times 10^{-5} \text{ m}^2/\text{m}$$

$$\begin{aligned} \text{no of Rivets/m} &= \frac{\text{Total Area/m}}{\text{Area of 1 rivet}} = \frac{4 \times 10^{-5}}{12.568 \times 10^{-6}} \\ &= 3.182 \text{ rivets/m} \\ &= 4 \text{ rivets/m} \end{aligned}$$

Question 5.



A weightless beam is hinged at the wall. Find the tension in the wire 'T' and the magnitude and direction of the force acting at the wall. [14 marks]

Space for calculations:

To Find T

TAKING MOMENTS ABOUT THE HINGE

$$T \sin 30 \times 3 = 50 \times 9 \times 5$$

Rearranging $T = \frac{50 \times 9 \times 5}{\sin 30 \times 3} = \frac{2452}{1.5} = 1635 \text{ N}$

To Find Forces at the wall

$$\text{Horizontal} = T \cos 30$$

$$= 1635 \times 0.866 = 1415 \text{ N}$$

Vertical - Take Moment about RH end

$$T \sin 30 \times 2 = \text{Force Vertical} \times 5$$

$$F_{\text{vertical}} = \frac{T \sin 30 \times 2}{5} = \frac{1635 \times 2}{5} = 327 \text{ N}$$

Resultant using Pythagoras

$$\begin{aligned} \text{Angle} &= \tan^{-1} \frac{327}{1415} \\ &= 12.9^\circ \\ &= \sqrt{1415^2 + 327^2} = 1421 \text{ N} \end{aligned}$$

Question 6

What are composite materials? Describe two common composite materials and discuss their advantages and disadvantages compared to metals. [16 marks]

Space for answer:

COMPOSITE → MEANS MADE FROM 2 OR MORE MATERIALS

COMMON COMPOSITES

GLASS FIBRE — GLASS FIBRES IN POLYESTER OR EPOXY RESIN

ADVANTAGES — CHEAP, CHEAP TO MAKE TOOLING, CAN MAKE COMPLEX SHAPES, DOES NOT CORRODE

DISADVANTAGES — NOT VERY STIFF, FAIRLY HEAVY, LABOUR INTENSIVE

CARBON FIBRE — CARBON FIBRES IN EPOXY RESIN

ADVANTAGES — STRONG, STIFF & LIGHT.

DISADVANTAGES — EXPENSIVE, LABOUR INTENSIVE

REINFORCED CONCRETE — STEEL WIRING OR GRID IN CONCRETE

ADVANTAGE — WILL TAKE TENSILE LOADS

FIBRE MATRIX COMPOSITE — BORON FIBRES IN LIGHT ALLOY MATRIX

ADVANTAGES — STIFFER AND HARDER WEARING THAN ALLOY ALONE

DISADVANTAGES — COST.

ALUMINIUM / NOMEX HONEYCOMB SANDWICH
ALUMINIUM / ALUMINIUM HONEYCOMB SANDWICH) STIFF & LIGHT.

ALUMINIUM / BalsaWOOD SANDWICH — STIFF & LIGHT.



PHASE TEST SPECIFICATION

Programme:	Foundation Engineering				
Module/Unit:	Engineering Science				
Test No:	1	Lecturer:	Abi Summerfield	Internal Verifier:	Chris Wyatt

Date:	May 22 nd 2009	Time:	11:00	Contribution to Overall Module/Unit Assessment (%):	50
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For the attention of all students:

Answer all the questions.

The mark allocation is as shown – Total 44 marks.

Formula sheets are provided for your reference.

Where appropriate consider 'g' = 9.81ms^{-2}

1. A Kinetic Energy Recovery System on a race car operates by making use of energy stored in a rotating flywheel. The car is charged by using an electric motor to get the flywheel up to its top speed of 3000rpm. One such flywheel is a homogeneous cylinder with a mass of 15kg and a radius of gyration of 0.15m.

a) What is the kinetic energy of the flywheel after charging? [7 marks]

b) If the car generates a torque of 50Nm, what power does it produce? [3 marks]

c) How long does it take to charge? [8 marks]

$$\omega = 3000 \text{ rpm} \times \frac{2\pi}{60} = 314.16 \text{ rad/s.} \quad (1)$$

a) $m = 15 \text{ kg}$
 $k = 0.15 \text{ m}$

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

$$I = mk^2 \quad (1)$$

$$I = 15 \times 0.15^2 \quad (1)$$

$$I = 0.3375 \text{ kg m}^2 \quad (1)$$

$$KE = \frac{1}{2} \times 0.3375 \times 314.16^2 \quad (1)$$

$$KE = 16.655.04 \text{ J.} \quad (1)$$

b) $T = 50 \text{ Nm}$

$$P = T\omega = 50 \times 314.16 = 15708 \text{ W} \quad (1)$$

c) $\omega_1 = 0$

$$\omega_2 = 314.16 \text{ rad/s.}$$

$$t = ?$$

$$\alpha = 11.85 \text{ rad/s}^2$$

$$T = I\alpha \quad (1)$$

$$\alpha = \frac{T}{I} \quad (1)$$

$$I = 0.3375$$

$$\alpha = 11.85 \text{ rad/s}^2 \quad (1)$$

$$\omega_2 = \omega_1 + \alpha t \quad (1)$$

$$t = \frac{\omega_2 - \omega_1}{\alpha} = \frac{314.16 - 0}{11.85} = 26.5 \text{ sec.} \quad (1)$$

2. At the start of its cycle a single cylinder compression ignition engine contains gas of initial pressure 1.35bar and ambient temperature of 18°C in a volume of 0.25 litres. The volume is then reduced until the gases pressure has increase to 38bar and the temperature is 355°C. Calculate the new volume of the gas and the compression ratio of the engine. [8 marks]

$$P_1 = 1.35 \times 10^5 \text{ N/m}^2$$

$$T_1 = (18 + 273) \text{ K}$$

$$V_1 = 0.25 \text{ L} \quad 0.5$$

$$P_2 = 38 \times 10^5 \text{ N/m}^2$$

$$T_2 = (355 + 273) \text{ K}$$

$$V_2 = ? \quad 0.5$$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \quad (1)$$

$$V_2 = \frac{P_1 V_1 T_2}{T_1 P_2} \quad (1)$$

$$V_2 = \frac{1.35 \times 10^5 \times 0.25 \times (355 + 273)}{(18 + 273) \times 38 \times 10^5} \quad (1)$$

$$V_2 = \cancel{24.1956} \quad 0.0192 \text{ L} \quad (1)$$

$$r = \frac{V_1}{V_2} = \frac{0.25}{0.0192} = 13.04:1 \quad (1)$$



PHASE TEST SPECIFICATION

Programme:	Foundation Engineering				
Module/Unit:	Engineering Science				
Test No:	1	Lecturer:	Abigail Summerfield & Mark Ellis	Internal Verifier:	Chris Wyatt

Date:	Mon 19 th May 2008	Time:	1pm- 2.30pm	Contribution to Overall Module/Unit Assessment (%):	50
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For the attention of all students:

Answer all the questions.

The mark allocation is as shown – Total 100 marks.

Formula sheets are provided for your reference.

Where appropriate consider 'g' = 9.81ms^{-2}

4. A flywheel of mass 2.5kg and radius of gyration 0.005m rotates from rest up to an angular velocity of 1800rpm in 13 seconds. Calculate:

- a) The angular acceleration, [4 marks]
- b) The torque of the flywheel, [6 marks]
- c) The power absorbed in accelerating the flywheel. [4 marks]

5. A compression ignition engine has a compression ratio of 15:1. The pressure and volume of mixture at the intake is 1.013 bar and 0.5 litres respectively and has a temperature of 17°C. If the pressure at the end of compression is 35 bar calculate the final volume and temperature of the gas

[10 marks]

Given that the gas has a mass of 0.025kg at the end of the compression calculate the universal gas constant. [4 marks]

6. The reciprocating components of an engine are considered to have a mass of 1.5kg and to move with Simple Harmonic Motion. When the piston is 30mm away from the centre of its oscillation it has a velocity of 25ms^{-1} , determine:

- a) The frequency of the oscillation, [8 marks]
- b) The stroke of the piston, [6 marks]
- c) The maximum velocity obtained by the piston, [4 marks]
- d) The maximum force acting on the body in kN. [4 marks]

Not in text.

$$\begin{aligned}
 A. \quad m &= 2.5 \text{ kg} \\
 K &= 0.008 \text{ m} \\
 \omega_1 &= 0 \\
 \omega_2 &= 1800 \times \frac{2\pi}{60} = 188.5 \text{ rad/s} \\
 t &= 13 \text{ s}
 \end{aligned}$$

$$a) \quad \alpha = ? \quad \omega_2 = \omega_1 + \alpha t$$

$$\begin{aligned}
 \omega_2 - \omega_1 &= \alpha t \\
 \alpha &= \frac{\omega_2 - \omega_1}{t}
 \end{aligned}$$

$$\alpha = \frac{188.5 - 0}{13} = 14.5 \text{ rad/s}$$

$$\begin{aligned}
 b) \quad T &= I \alpha & I &= m k^2 \\
 T &= 6.25 \times 10^{-5} \times 14.5 & I &= 2.5 \times 0.008^2 \\
 T &= 9.0625 \times 10^{-4} \text{ Nm} & I &= 6.25 \times 10^{-5} \text{ kg m}^2
 \end{aligned}$$

$$\begin{aligned}
 c) \quad P &= T \omega \\
 P &= 9.06 \times 10^{-4} \times 188.5 \\
 P &= 0.17 \text{ N}
 \end{aligned}$$

$$\begin{aligned}
 5. \quad r &= \frac{V_1}{V_2} = \frac{15}{1} & P_1 &= 1.013 \text{ bar} & P_2 &= 35 \text{ bar} \\
 & & V_1 &= 0.5 \text{ l} & V_2 &= ? \\
 & & T_1 &= (17+273) \text{ K} & T_2 &= ?
 \end{aligned}$$

$$\therefore r_2 = \frac{V_1}{r} = \frac{0.5}{15} = 0.033 \text{ l}$$

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

$$T_2 = \frac{P_2 V_2 T_1}{P_1 V_1} = \frac{35 \times 0.033 \times (17+273)}{1.013 \times 0.5}$$

$$T_2 = 667.98 \text{ K}$$

5. Continued.

$$m = 0.025$$

$$P = 35 \times 10^5 \text{ N/m}^2$$

$$V_2 = 0.033 \text{ L} = 3.3 \times 10^{-5} \text{ m}^3$$

$$T_2 = 667.98 \text{ K}$$

$$V_1 = 0.001 \text{ m}^3$$

$$PV = mRT$$

$$R = \frac{PV}{mT}$$

$$R = \frac{35 \times 10^5 \times 3.3 \times 10^{-5}}{0.025 \times 667.98}$$

$$R = 6.92 \text{ J/kg/K}$$



**SWANSEA INSTITUTE
ATHROFA ABERTAWE**

*Faculty of Applied Design
and Engineering*

PHASE TEST SPECIFICATION

Programme:	Foundation Engineering				
Module/Unit:	Engineering Science				
Test No:	1	Lecturer:	Abigail Summerfield & Mark Ellis	Internal Verifier:	Chris Wyatt

Date:	Tuesday 8th May 2007	Time:	9 am	Contribution to Overall Module/Unit Assessment (%):	50
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For the attention of all students:

Answer all the questions.

The mark allocation is as shown – Total 90 marks.

Formula sheets are provided for your reference.

Where appropriate consider 'g' = 9.81ms^{-2}

4 The rotating parts of an engine may be considered to have a mass of 4.5kg acting at a radius of gyration of 0.15m. The mass of the engine as a whole is 85kg and it is propelling a vehicle at 45 km/h whilst rotating at a speed of 2500rev/min.

Determine:

- a. The kinetic energy of the rotating parts. [4 marks]
- b. The kinetic energy of the engine. [2 mark]
- c. The kinetic energy of the whole system. [2 mark]

This engine is then lifted from the vehicle; where it was mounted 0.3m above the ground to 1m for maintenance, calculate:

- d. The change in potential energy of the engine. [4 marks]

5a. Explain what you know of Charles Law. [2 mark]

b. Explain what you know of Boyles Law. [2 mark]

c. The compression ratio of an engine is 14 to 1; the pressure at the commencement of the compression stroke is 250kN/m^2 absolute and the temperature 125°C . Calculate the absolute pressure at the end of the compression stroke if the temperature has then risen to 195°C . [12 marks]

6. A pipe has three cross sections X, Y, and Z of diameters 0.1m, 0.25m and 0.5m respectively calculate the velocities of a fluid at each of the cross sections given the flow rate is $2\text{m}^3/\text{s}$. Find the percentage decrease in velocity from A to C.

[12 marks]

1. Rotary

$$m = 4.5 \text{ kg}$$

$$r = 0.15 \text{ m}$$

$$\omega = \frac{2500 \times 2\pi}{60} = 261.8 \text{ rad/s}$$

Linear

$$m = 85 \text{ kg}$$

$$v = 45 \text{ km/h} = 12.5 \text{ m/s}$$

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

$$KE = \frac{1}{2} \times 0.10125 \times 261.8^2$$

$$= 3469.8 \text{ J}$$

$$I = mr^2$$

$$I = 4.5 \times 0.15^2$$

$$I = 0.10125 \text{ kg m}^2$$

$$b) \quad KE = \frac{1}{2} mv^2 = \frac{1}{2} \times 85 \times 12.5^2$$

$$KE = 6640.625 \text{ J}$$

$$c) \quad \text{Total KE} = 3469.8 + 6640.625$$
$$= 10110.425 \text{ J}$$

$$d) \quad PE @ \overset{\text{Top}}{\text{Bottom}} - PE @ \overset{\text{Top}}{\text{Bottom}}$$

$$= mgh - mgh$$

$$= (85 \times 9.81 \times 1) - (85 \times 9.81 \times 0.3)$$

$$= 583.695 \text{ J}$$

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$$c) \quad r = \frac{V_1}{V_2} = \frac{14}{1}$$

$$P_1 = 250 \text{ kN/m}^2$$

$$P_2 = ?$$

$$T_1 = (125 + 273) \text{ K}$$

$$T_2 = (195 + 273) \text{ K}$$

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

$$P_2 = \frac{P_1 V_1 T_2}{T_1 V_2} = \frac{250 \times 14 \times (195 + 273)}{(125 + 273) \times 1}$$

$$P_2 = 4115.6 \text{ kN/m}^2.$$