GD652

OLLSCOIL NA hÉIREANN

The National University of Ireland

National University of Ireland, Galway

Trinity Examinations, 2000/01

First Year Mechanical, Biomedical & Undenominated Engineering Examination

FUNDAMENTALS OF MECHANICAL ENGINEERING

Professor J.J. O' Connor
Professor J.F. McNamara
Professor P.J. Nolan, Dr. P. McHugh
Dr. C. Ó Brádaigh,Dr. J.A. Eaton
Dr. P. Molloy, Dr. N. Quinlan
Dr. M. Bruzzi

Attempt *Four* Questions
Time Allowed: 2 Hours

1(a) Discuss car frames (chassis) under the following headings:

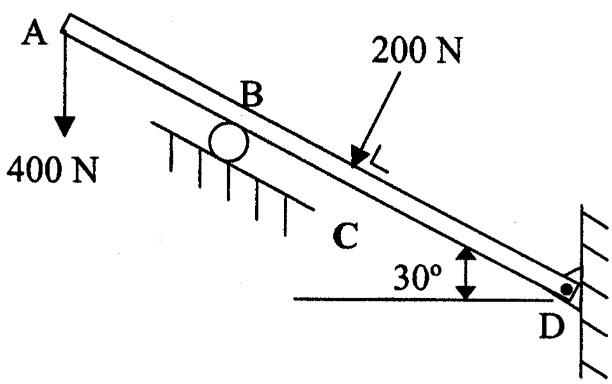
(i) Different structural types
(ii) Purpose and functions of car frames.

(3)

(b) Define and comment on each of the following terms:

(i) Force
(ii) Moment
(iii) Rigid Body
(iv) Free Body Diagram
(v) Static Equilibrium *(5)*

A beam supported by a pin joint at D, rests on a frictionless roller at B with forces applied at A and C as shown in Figure 1. Draw a Free Body Diagram and calculate the force on the roller at B. Also, calculate the magnitude and direction of the force at the pin joint at D. *(12)*



Beam Length = 8.0 m
AB = 2.0 m
BC = 2.0 m
CD = 4.0 m
Neglect the mass of beam

Figure 1

2. A 1.6 litre four-cylinder four-stroke spark ignition engine is designed and built subject to the constraint that temperature in the cylinder cannot exceed 1200°C. In a test, the following parameters are measured:

speed:	5000 rpm
brake power:	60.8 kW
fuel consumption:	4.04 g/s
ambient temperature:	25°C

The fuel is petrol with a calorific value of 48.34 MJ/kg.

(a) What is the highest thermal efficiency an engine could possibly achieve at the above ambient temperature and with the above constraint on cylinder temperature? ***(6)***

(b) What is the overall efficiency of the actual engine? ***(6)***

(c) What is the brake mean effective pressure (bmep) in the actual engine? ***(8)***

Useful equations

$Q_H/Q_L = T_H/T_L$ for an ideal engine

$W_b = \text{bmep} \times V_d \quad \eta_o = \dot{W}_b/(\dot{m}h_{RP})$

$\eta_{th} = 1 - \frac{1}{r^{\gamma-1}}$ for the Otto cycle.

3(a) Explain the difference between kinematics and kinetics ***(3)***

(b) A crank is a machine element but what exactly does it do and can you show examples of it in different mechanisms ***(9)***

(c) Show how a cam which will give a follower simple harmonic motion may be created and derive equations showing displacement, velocity, acceleration and jerk. ***(8)***

4(a) Briefly explain the different reasons for fluid dynamic resistance *(4)*

(b) An old car can just manage a top speed of 100km/hour at sea level in Galway where the temp is 20°C, the air pressure is 101350 Pa and the air density is 1.2kg/m^3. The car has a drag coefficient of 0.38 and a frontal area of 1.92m^2. What is drag force for the car when moving at top speed and how much power is absorbed in overcoming aerodynamic resistance *(8)*

(c) It is planned to drive the same car in the Alps at an altitude of 3000m. If the engine power and rolling resistance are the same find the maximum speed that can be reached on a level surface. *(8)*

Useful Formulae:

1. $D = C_D\,(0.5\rho V^2)A_{PROJ}$

2. $p = \rho RT$

3. $T(z) = T_0 - Bz,\qquad B = 0.0065\ K/m$

4. $p = p_a(1 - Bz/T_0)^{5.26}$

5. Detail the material advances being made in automobiles to advance light weight and better fuel efficiency. List the advantages and disadvantages of new materials being considered. *(20)*

6. A common example of a slider-crank mechanism is found in reciprocating engines. If the crank has a rotational speed of 1500rpm determine, for the position where the crank angle is 60^0, the velocity of the piston A. Also determine the velocity of point G on the connecting rod. *(20)*

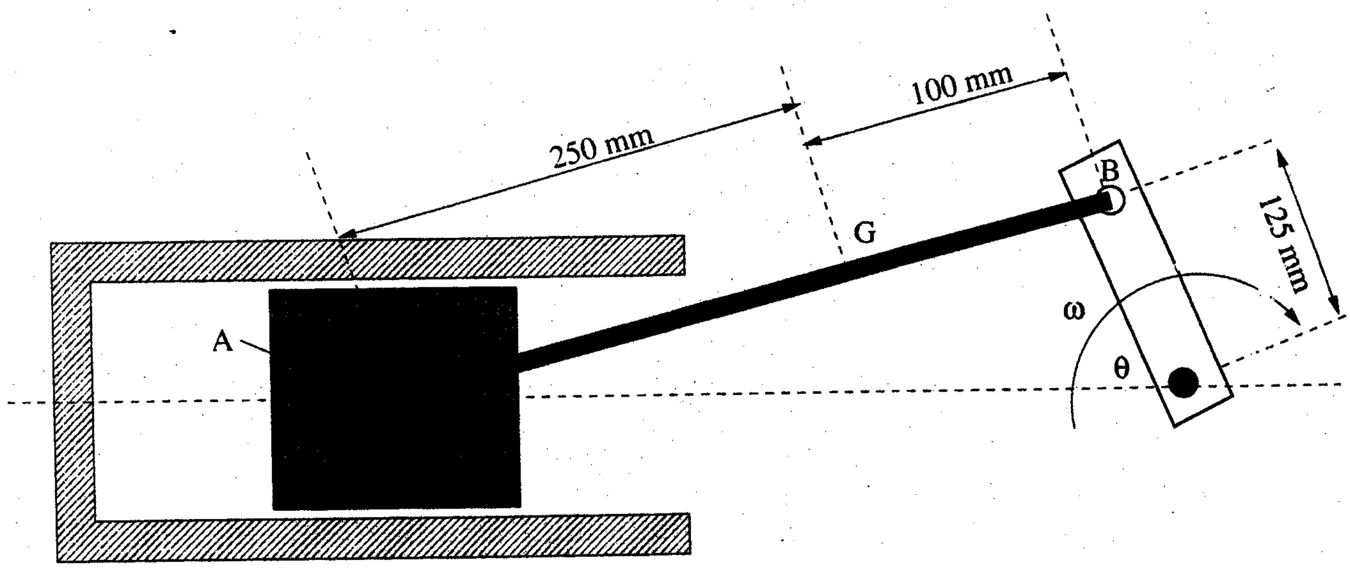


Figure 6

-D 652

7. The model depicted in Figure 7 is the so-called unicycle model for studying the vertical vibrations of a vehicle travelling over a rough road. A spring mounted trailer has a mass of 500kg. and, during loading, it was observed that each 75kg. added caused the trailer to sag by 3mm.
Determine the natural frequency of the system. If the undulations in the road can be represented as a sine wave with period 1.2m and height 50mm, determine:

(a) Critical speed *(12)*
(b) Peak displacement for a speed of 25km/hour. *(8)*

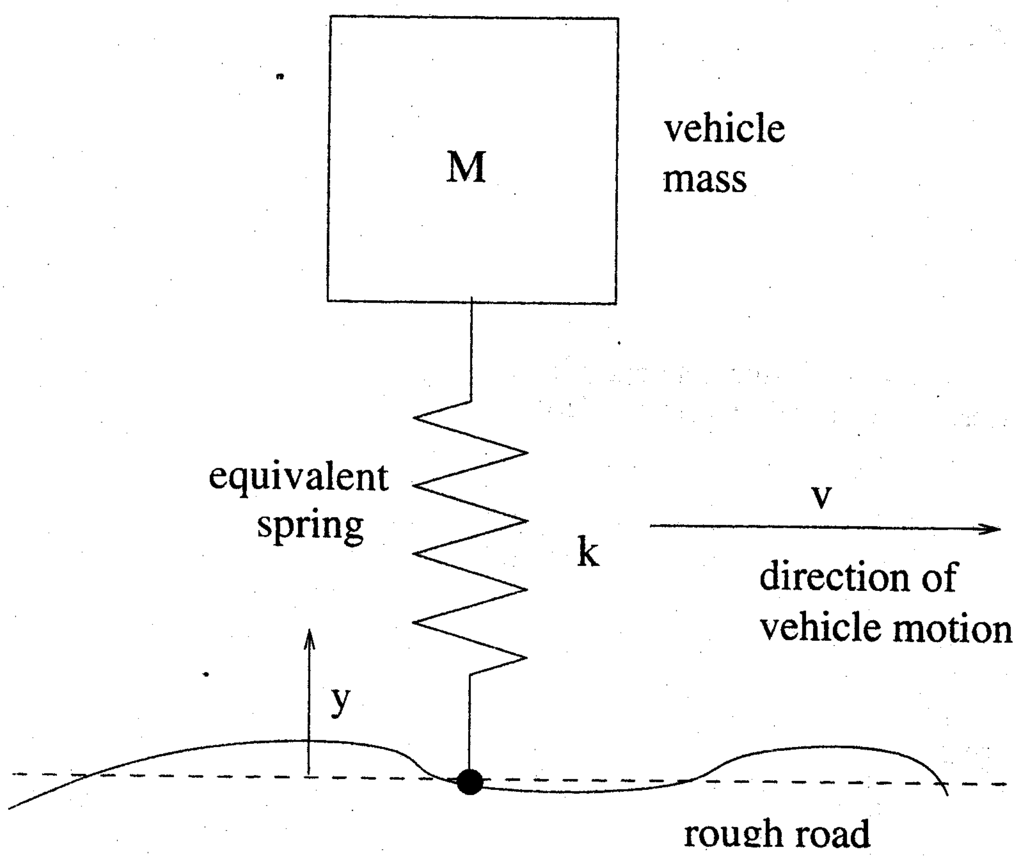


Figure 7

8(a) Using sketches, define and discuss axial and shear strain and normal and shear stress. With a very simple example demonstrate why stress and strain can vary within a body under load. Why are stress and strain distributions within a body important to an engineer?

(10)

(b) Consider a camshaft in an engine that is supported at both ends and that operates 3 sets of valves as shown schematically in Figure 8. The cams are spaced equally from each other and from the end supports by a distance d (40 mm). If the valve opening force is known to be 10,000 N calculate the maximum stress in the camshaft when cam 2 is in operation. Discuss the the acceptability of this design if the yield strength of the steel from which the camshaft is made is 1,000 MPa. Assume that the shaft is circular and that the formula for the second moment of area of a shaft is $\pi D^4/64$, where D is the shaft diameter (30 mm).

(10)

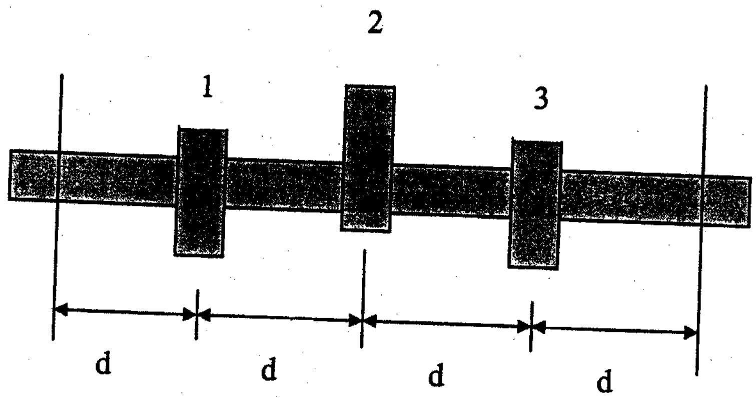


Figure 8