



EXAMINATIONS 2011 / 2012 **AHOLIADAU 2011 / 2012**

Semester 2

FACULTY OF: Applied Design & Engineering

NAME OF COURSE/PROGRAMME: BEng Manufacturing Systems Engineering
BEng Mechanical & Manufacturing Engineering

YEAR OR LEVEL: Year 2 – PART TIME

NAME OF MODULE/UNIT/EXAM PAPER: Stress Analysis and Dynamics

MODULE NO:

DATE OF EXAMINATION: 22/06/12

EXAMINATION TIMES:

START TIME: 1:30 pm

FINISH TIME: 3:30pm

TIME ALLOWED: 2 hours

INSTRUCTIONS TO CANDIDATES:

Answer 3 from 4 questions.

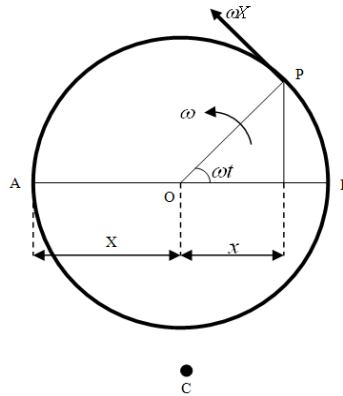
Assume acceleration due to gravity, $g = 9.81 \text{ ms}^{-2}$

Attach any graph paper used to your answer booklet

Question 1

- a. Consider point P rotating about point O at a constant angular velocity, ω , as shown in the below figure. When viewed from position C point P appears to move with simple harmonic motion. Prove that the velocity, v , of P, when viewed from C, is given by $v = \omega\sqrt{(X^2 - x^2)}$. When would P appear to have its greatest velocity when viewed from position C.

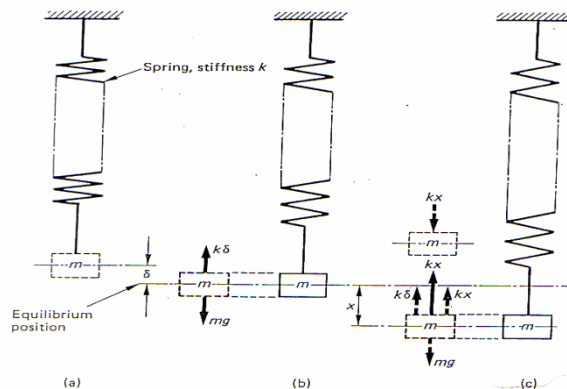
[5 Marks]



- b. Consider a mass on a spring as shown below, show that the natural frequency is given by

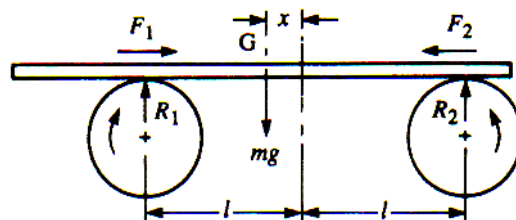
$$f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$$

[5 Marks]



- c. A thin uniform bar of mass, m , is placed on two identical discs which rotate with equal but opposite speeds as shown below. Show that if the centre of gravity of the bar is displaced from the mid position by a distance x , that the bar will oscillate with a periodic time given by $T = 2\pi \sqrt{\left(\frac{I}{\mu g}\right)}$ where μ is the coefficient of friction between the discs and the bar and $2l$ is the distance between the centres of the two discs.

[10 Marks]



Question 2

- a. A 3 ton truck is hauled up an incline of 1 in 20 (5%) by a rope which is parallel to the incline and which winds onto a 1.2m diameter winding drum at the top of the incline. The winding drum has a mass of 0.5 tons and a radius of gyration of 0.5m, and is coupled through a transmission unit to an electrical drive motor. The mechanical efficiency of the transmission unit is 85% and the frictional resistance to motion is 1.0kN at all times. If the velocity and acceleration of the truck at a particular instance are 1m/s and 0.1ms^{-2} respectively, calculate the corresponding power output from the electric motor. Neglect the weight of the rope throughout your analysis.

[10 Marks]

- b. The motor in (a) is used to haul the truck from rest at time zero, up the incline until it reaches a speed of 1.5ms^{-2} . The power output from the motor is then reduced to maintain this velocity for a further 15 seconds, at which time the motor is switched off and the truck is allowed to coast.

- i. Draw a velocity v time graph showing the motion of the truck from time zero until it is just about to start rolling back down the hill.

[6 Marks]

- ii. How Far will the truck have travelled before it starts rolling back down the hill?

[1 Mark]

- iii. Mark on the graph the point where the power of the motor was calculated in (a).

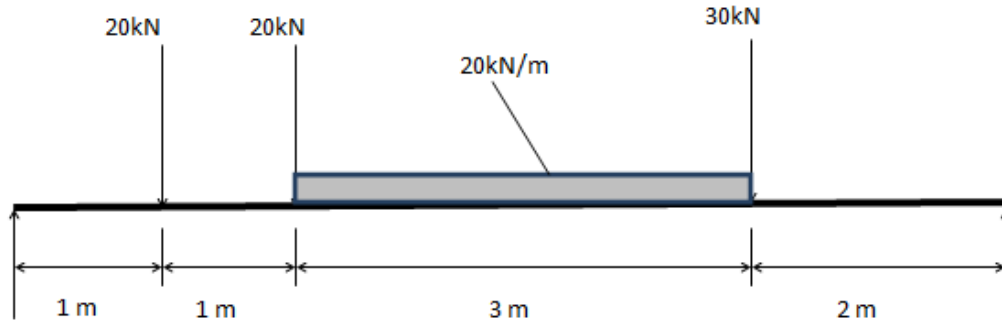
[1 Mark]

- iv. Using your answer to (a) and assuming a linear relationship between power (J/sec) and velocity (m/s) calculate the total energy output from the electric motor.

[2 Marks]

Question 3

For the beam shown below, derive expressions for the slope and deflection and find the deflection at mid-point.



Take $EI = 65 \text{ MNm}$

[20 marks]

Question 4

- a) For the element of material shown below, use graphical methods to determine:
- Maximum and minimum principal stresses
 - Maximum shear stress
 - The orientation of the principal planes and planes of maximum shear. Show the orientation of these planes on an appropriate element diagram.

[12 marks]

- b) Use analytical methods to confirm the values obtained in a) above.

[6 Marks]

- c) Determine the direct and shear stresses acting on a plane 30° clockwise from the plane of the 30 MPa stress.

[2 Marks]

FORMULA SHEET

Free Vibrations;

$$v = \omega \sqrt{(X^2 - x^2)}$$

$$a = \omega^2 x$$

$$f = \frac{1}{T} = \frac{\omega}{2\pi}$$

Dynamics

Assume $g = 9.81 \text{ms}^{-2}$ in all calculations

$$\text{Centripetal Force} = \frac{mv^2}{r}$$

Momentum = Mass x Velocity

Force = Mass x Acceleration

$$T = I\alpha$$

$$I = mk^2$$

$$\text{Kinetic Energy} = \frac{1}{2} mv^2$$

Linear acceleration

$$v = u + at$$

$$s = ut + \frac{1}{2} at^2$$

$$v^2 = u^2 + 2as$$

Complex stress

$$\sigma_{1,2} = \frac{1}{2} \left[(\sigma_x + \sigma_y) \pm \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2} \right]$$

$$\tau_{\max} = \frac{1}{2} (\sigma_1 - \sigma_2)$$

$$\tau_{\max} = \frac{1}{2} \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}$$

Angle of principle plane given by;

$$\tan \theta = \frac{\sigma_p - \sigma_x}{\tau_{xy}}$$