Faculty of Engineering and Design

Carleton University

Final Examination - April 2014.

Date: Apr 13, 2014 | No of Students: 925

Time: 2:00-5:00pm

Course: ECOR 1101 Engineering Mechanics: Sections B, C, D, E & F.

Department: Civil and Environmental Engineering

Course Instructors: Professors Salinas, Sarkar, Sivathayalan, and Vandenberg

Authorized Memoranda

Calculator ONLY.

(Programmable calculators with less than 4MB RAM permitted).

(Handheld computers, Cellphones, Smartphones etc. not permitted)

Instructions:

1. Write your name, student number and place your signature in the space provided below.
2. Circle your lecture section and P/A class section in the table below.
3. This examination has **EIGHT** pages. Make sure you have all the pages.
4. **Answer ALL Questions**.
5. Answer the questions in the space provided. You can use the facing page, and/or the back of the page if you require additional space. Clearly mark the question number if you make use of this additional space.
6. **This examination is closed book**. You are not allowed to have any unauthorized material on the desk or in your pockets.
7. Do not ask any questions. If you feel that information given is incomplete or incorrect, make reasonable assumptions as required and proceed with the solution. Make sure your assumptions are clearly stated.
8. Note that all surfaces are to be considered smooth (thus friction must be neglected in all questions).
9. Your answers should be clearly presented, and you should provide appropriate intermediate steps, and free body diagrams when relevant.

Name: ____________________

Student Number: ____________________

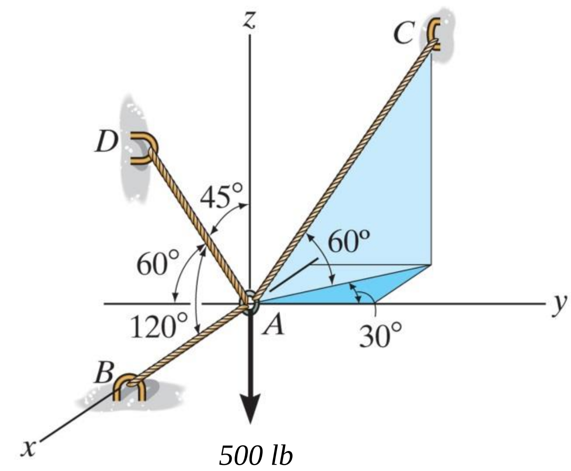
Signature: ____________________

Circle Lecture & P/A Sections:

Lecture Section:	B	C	D	E	F
P/A Class Section:	1	2	3	4	5

For Instructor Use ONLY		
Question	Max Mark	Mark
Q1	20	
Q2	20	
Q3	20	
Q4	20	
Q5	20	
Total		

Q1. A 500 lb downward vertical force is applied on a small ring at A supported by three cables as shown in the figure. Determine the force developed in cables AB, AC and AD.

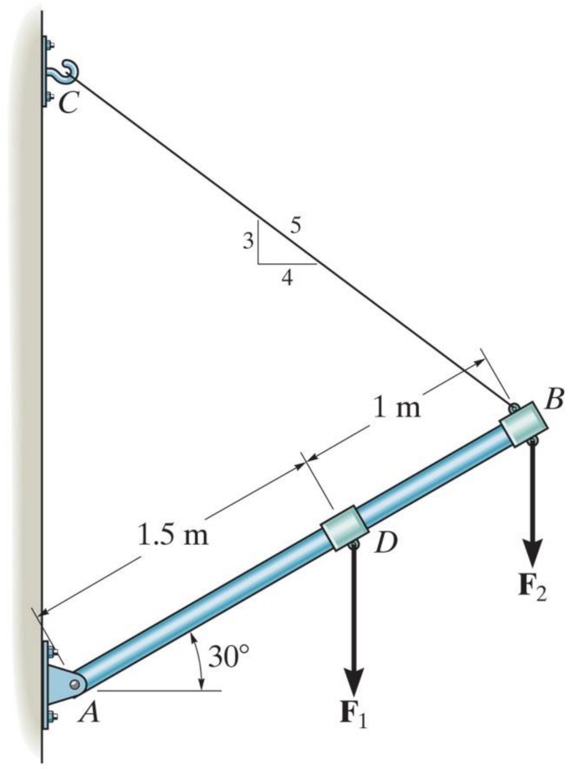


Q2. The maximum allowable tension in cable BC is 2500 N.

Determine the

a) maximum loads F_1 and F_2, if $F_1 = 2F_2$

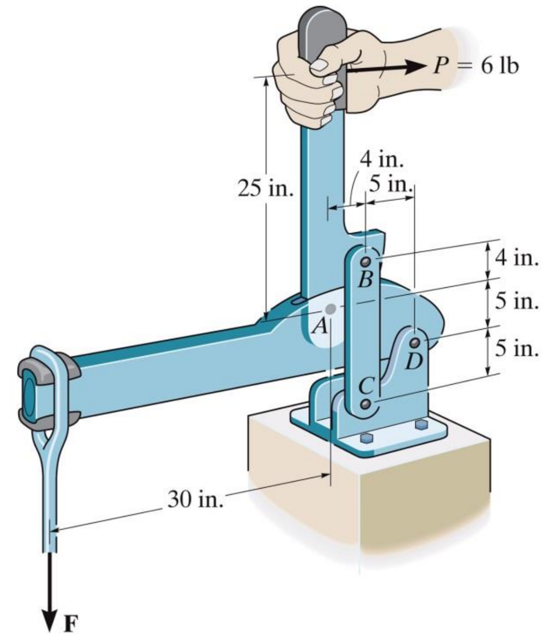
b) Support reactions at A under the maximum loads.



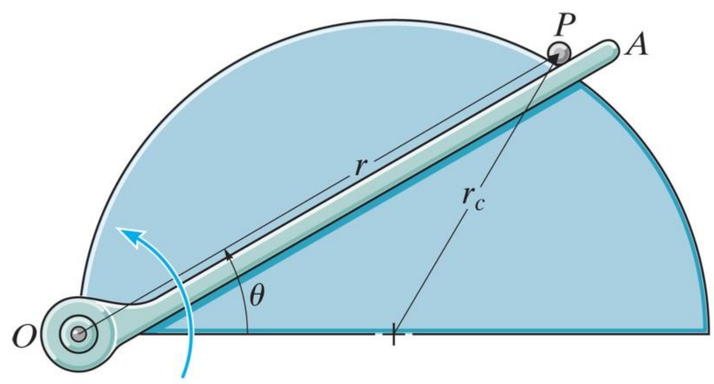
Q3. A horizontal force of P = 6 lb is applied on the handle to support a vertical force F as shown in the figure. The members are connected by smooth pins at A, B, C, and D.

a) Determine the magnitude of the force F required for equilibrium

b) Determine the internal forces (normal, shear forces and the bending moment) at the midpoint of member BC

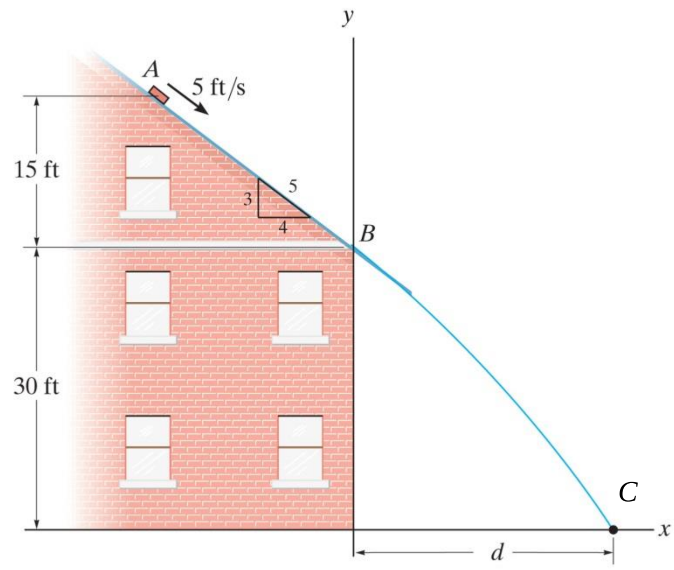


Q4. A 0.5 lb smooth ball is guided along the vertical circular path $r = 2r_c\,cos(\theta)$ using the arm OA. The arm has an angular velocity of $\dot{\theta} = 0.4\ rad/s$ and angular acceleration of $\ddot{\theta} = 0.8\,rad/s^2$ at the instant $\theta = 30°$. Determine the force exerted on the ball by the arm at this instant ($\theta = 30°$) if $r_c = 0.5\,ft$. Neglect the size of the ball.



Q5. The 2-lb brick slides down a smooth roof. It has a speed of 5 ft/s at point A as shown. It falls off the roof at point B, and strikes the ground at C at a distance of d from the wall. Determine the

a) speed of the brick just before it leaves the roof at B
b) the distance d
c) The speed at which the brick hits the ground



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If you want to use this page, please clearly identify the question number.

Equations of Statics

Vectors

Cartesian Vector $\overline{\boldsymbol{A}} = A_x\,\bar{\boldsymbol{\imath}} + A_y\,\bar{\boldsymbol{\jmath}} + A_z\overline{\boldsymbol{k}}$

Magnitude $A = \sqrt{A_x^2 + A_y^2 + A_z^2}$

Unit vector $\overline{\boldsymbol{u}}_A = \frac{\bar{A}}{A} = \frac{A_x}{A}\bar{\boldsymbol{\imath}} + \frac{A_y}{A}\bar{\boldsymbol{\jmath}} + \frac{A_z}{A}\overline{\boldsymbol{k}}$

Unit vector using direction cosines

$$\overline{\boldsymbol{u}}_A = \cos(\alpha)\,\bar{\boldsymbol{\imath}} + \cos(\beta)\,\bar{\boldsymbol{\jmath}} + \cos(\gamma)\,\overline{\boldsymbol{k}}$$

Dot Product $\overline{\boldsymbol{A}} \cdot \overline{\boldsymbol{B}} = A\,B\,Cos(\theta)$

$\overline{\boldsymbol{A}} \cdot \overline{\boldsymbol{B}} = A_xB_x + A_yB_y + A_zB_z$

Cross Product

$$\overline{\boldsymbol{C}} = \overline{\boldsymbol{A}} \times \overline{\boldsymbol{B}} = \begin{vmatrix} \bar{\imath} & \bar{\jmath} & \bar{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

Cartesian Position Vector

$$\bar{\boldsymbol{r}}_{AB} = (x_B - x_A)\,\bar{\boldsymbol{\imath}} + (y_B - y_A)\,\bar{\boldsymbol{\jmath}} + (z_B - z_A)\,\overline{\boldsymbol{k}}$$

Cartesian Force Vector

$$\overline{\boldsymbol{F}}_{AB} = F\,\overline{\boldsymbol{u}}_{AB} = F\,\frac{\bar{\boldsymbol{r}}_{AB}}{|\bar{\boldsymbol{r}}_{AB}|}$$

Moments

Moment of a force

Scalar Formulation $M_o = F\,d$

Vector Formulation $\overline{\boldsymbol{M}}_o = \bar{\boldsymbol{r}} \times \overline{\boldsymbol{F}}$

$$\overline{\boldsymbol{M}}_o = \begin{vmatrix} \bar{\imath} & \bar{\jmath} & \bar{k} \\ r_x & r_y & r_z \\ F_x & F_y & F_z \end{vmatrix}$$

Moment of a force about a specified axis aa (unit vector $\bar{u}_{aa}$)

$$M_{aa} = \bar{u}_{aa} \cdot (\bar{\boldsymbol{r}} \times \overline{\boldsymbol{F}}) = \begin{vmatrix} u_x & u_y & u_z \\ r_x & r_y & r_z \\ F_x & F_y & F_z \end{vmatrix}$$

Simplification of a force and couple system

$$\overline{\boldsymbol{F}}_R = \sum \overline{\boldsymbol{F}}\,;\ (\overline{\boldsymbol{M}}_R)_O = \sum \overline{\boldsymbol{M}} + \sum (\overline{\boldsymbol{M}})_O$$

Equilibrium

Particle equilibrium

$$\sum F_x = 0;\ \sum F_y = 0;\ \sum F_z = 0;$$

Rigid body equilibrium in 2D

$$\sum F_x = 0;\ \sum F_y = 0;\ \sum M_O = 0;$$

Rigid body equilibrium in 3D

$$\sum F_x = 0;\ \sum F_y = 0;\ \sum F_z = 0;$$
$$\sum M_x = 0;\ \sum M_y = 0;\ \sum M_z = 0;$$

Equilibrium equations: Vector formulation

$$\sum \overline{\boldsymbol{F}} = 0;\ \sum \overline{\boldsymbol{M}}_o = 0;$$

Centre of Gravity

$$\bar{x} = \frac{\sum x_i W_i}{\sum W_i}\ or\ \bar{x} = \frac{\int x\,dW}{\int dW}$$

Unit Conversion: $1m = 3.28\,ft.$

Equations of Dynamics

Particle Rectilinear Motion

Basic Relationships	For Constant acceleration a_c
$a = \frac{dv}{dt}$	$v = v_0 + a_c t$
$v = \frac{ds}{dt}$	$s = s_0 + v_0 t + \frac{1}{2}a_c t^2$
$a ds = v dv$	$v^2 = v_0^2 + 2a_c(s - s_0)$

Particle Curvilinear Motion

x, y, z Coordinates

$v_x = \dot{x}$ $\quad a_x = \dot{v}_x = \ddot{x}$

$v_y = \dot{y}$ $\quad a_y = \dot{v}_y = \ddot{y}$

$v_z = \dot{z}$ $\quad a_z = \dot{v}_z = \ddot{z}$

n, t, b Coordinates

$v = \frac{ds}{dt} = \dot{s}$ $\quad a_t = \dot{v} = v\frac{dv}{ds}$

$$\rho = \frac{\left[1 + \left(\frac{dy}{dx}\right)^2\right]^{3/2}}{\left|\frac{d^2y}{dx^2}\right|} \qquad a_n = \frac{v^2}{\rho}$$

r, θ, z Coordinates

$v_r = \dot{r}$ $\quad a_r = \ddot{r} - r\dot{\theta}^2$

$v_\theta = r\dot{\theta}$ $\quad a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta}$

$v_z = \dot{z}$ $\quad a_z = \dot{v}_z = \ddot{z}$

Relative Motion

$\bar{\boldsymbol{v}}_B = \bar{\boldsymbol{v}}_A + \bar{\boldsymbol{v}}_{B/A}$ $\quad \bar{\boldsymbol{a}}_B = \bar{\boldsymbol{a}}_A + \bar{\boldsymbol{a}}_{B/A}$

Equations of Motion

Particle	Rigid Body as particle
$\sum \boldsymbol{F} = m\bar{\boldsymbol{a}}$	$\sum \boldsymbol{F} = m\bar{\boldsymbol{a}}_{\boldsymbol{G}}$
$\sum F_x = ma_x$	$\sum F_x = m(a_G)_x$
$\sum F_y = ma_y$	$\sum F_y = m(a_G)_y$
$\sum F_z = ma_z$	$\sum F_z = m(a_G)_z$

Work- Energy

Work $U_{1\to 2} = \int \bar{F}.d\bar{r} = \int F\cos(\theta)\,ds$

Principle of Work-energy

$$\frac{1}{2}mv_1^2 + U_{1\to 2} = \frac{1}{2}mv_2^2$$

Conservation of Mechanical energy

$$\frac{1}{2}mv^2 + mgh + \frac{1}{2}ks^2 = constant$$

Where $\frac{1}{2}mv^2 \Rightarrow Kinetic\ energy$

$mgh \Rightarrow Gravitational\ Potential\ energy$

$\frac{1}{2}ks^2 \Rightarrow Elastic\ Potential\ energy$