SAULT COLLEGE OF APPLIED ARTS & TECHNOLOGY

SAULT STE. MARIE, ONTARIO

COURSE OUTLINE

Course Title:	MECHANICS OF MACHINES
Code No.:	MCH 205-4
Program:	MECHANICAL TECHNOLOGY
Semester:	
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Chli rperson ^ Date

MECHANICS OF MACHINES

Course Name

MCH 205-4

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PHILOSOPHY/GOALS:

METHOD OF ASSESSMENT {GRADING METHOD):

REFERENCE
TEXTBOOK(S):

Mechanics of Machinery - Ham, Crane & Rogers (McGraw-Hill)
Applied Kinematics - A.J. Ramous (Prentice-Hall)

MECHANICS OF MACHINES

MCH 205-4

TOPIC NO.	TOPIC INFORMATION
	Relative acceleration and acceleration po1ygon
	Static force analysis of machinery with and without friction
	Review of Dynamics Inertia forces on bodies in translation and applied rotation and plane motion
4	Inertia force analysis of mechancism

PROVIDED THERE IS TIME, THE FOLLOWING MAY BE COVERED:

5	Balancing rotating masses
6	Vibrations & Critical Speeds in Shafts
7	Balancing reciprocating masses

MECHANICS OF MACHINES

MTY-3

Part //I - "Relative Acceleration - "Acceleration Polygon"

GENERAL OBJECTIVE:

The student will be able to solve for the acceleration of any point on a mechanism by the method of "RELATIVE VELOCITIES".

SPECIFIC OBJECTIVES:

1. To be able to define acceleration of a point.
2. To be able to define average acceleration and instantaneous acceleration.
3. To be able to state that a capital V or A stands for the vector quantity of velocity and acceleration, while the lower case v or a stands for the magnitude of the velocity or acceleration.

4. To be able to list and state that:
   a) the normal component of acceleration is: $a_A = v \frac{dr}{dt}$
   and is perpendicular to the direction of V_A, towards the center of rotation.

   b) the tangential component of acceleration is $a_A = \frac{dv}{dt}$
   and is parallel to the direction of V_A in the direction of the angular acceleration point "A".

   c) the acceleration of point "A^n is: $A_A = A_A + A_A$

5. To be able to state and list that for a point on a link moving about a center of rotation:
   a) $a = Rw = \frac{v^2}{R}$ (Radius of Curvature = R)
   b) $a^t = R\alpha$

) $\mathbf{a} = \sqrt{(a^n)^2 + (a^t)^2}$

MECHANICS OF MACHINES

MTY-3

Part #1 - Continued

6. To be able to state that the acceleration of a point "A" relative to a point "B" is equal to the vector difference of the absolute acceleration of A and B.

$$\vec{a}_A = \vec{a}_B + \vec{a}_{AB}$$

$$\vec{a}_{AB} = \vec{a}_A - \vec{a}_B$$

7. To be able to state that given: $\tan\theta = \frac{a_n}{a_t} = \frac{\omega^2}{\alpha}$

the angle θ is independent of the location of the two points A and B and is dependent only upon the angular velocity and the angular acceleration of the body

8. To be able to state and use the following relationship to solve for A_.

$$\vec{a}_B = \vec{a}_A + \vec{a}_{BA}$$

9. To be able to state and realize that instantaneous centers as defined and used for velocity analysis cannot be used for acceleration analysis.

10. To be able to draw the acceleration polygon for a four link mechanism using the following formulas and solve for:

3) $\vec{a}_A = \vec{a}_n + \vec{a}_t$ $\quad$ $\vec{V}_B = \vec{V}_A + \vec{V}_{BA}$

b) $a_A = \omega_2^2 r_2$ $\quad$ $\vec{v}_A = \omega_2 \times \vec{r}_A$

c) $a_t = \alpha_2 r_2$

d) $\vec{a}_B = \vec{a}_A + \vec{a}_{BA}$

11. To be able to construct the acceleration polygon for a slider-crank mechanism.

12. To be able to construct the acceleration polygon for a FOUR LINK mechanism using the COMPLETE GRAPHICAL METHOD.

13. To be able to use and understand the "RITTERHAUS CONSTRUCTION" for solving for velocity & acceleration polygons for the slider-crank mechanism.-

PART 2 - STATIC FORCES IN MACHINES

General Objectives - To have a sound knowledge of how static forces act on machines and how they are transferred through machines.

Specific Objectives:

1) To be able to define (a) Static force analysis (b) dynamic force analysis.

2) To be able to state where forces are applied to machine members.

3) To be able to state where contact forces between two machine members occur in a turning or a sliding joint.

4) To be able to analyse the forces acting in a Bell Crank, (fig 10.1)

5) To be able to analyse the forces acting in an Engine Mechanism (fig 10.2).

6) To be able to analyse the forces acting in a Drag-link Mechanism.

7) To be able to list motion-resisting forces such as a) resistance to sliding (b) resistance to rolling.

8) To be able to state the law of proportionality.

9) To be able to define a) Dry friction (b) thick film (c) Thin film or boundary fabrication.

10) To be able to state that the coefficients of static friction are higher than coefficients of sliding friction.

11) To be able to.analyse the forces in a sliding joint and in a turning joint.

12) To be able to define friction circle in a turning joint.

13) To be able to do a friction analysis of a higher pair.

14) To be able to discuss the magnitudes of the coefficient of friction.

15) To be able to carry out a friction analysis of a Bell Crank.

16) To be able to define efficiency of a machine.

17) To be able to list the formula for efficiency

a) $\text{Eff} = \frac{Wj - Wf}{V?i} = \frac{W_2}{W2 + Wf}$

b) $\text{Eff} = \frac{Wi - Wf}{Wi} = \frac{Qa}{Qoq} = \frac{Q}{Qo}$

c) $\text{Eff} = \frac{W2}{W2 + Wf} = \frac{P \circ P}{Pp} = ??$

18) To be able to analyse the effect of friction in the Engine Mechanism.

19) To be able to define (a) equivalent turning effort (b) instant-aneous efficiezicy-

20) To be able to analyse the effect of friction in a stone crusher.

21) To be able to analyse the effect of friction in a cam mechanism and list the formula for efficiency for a cam.

22) To be able to analyse the effect of friction on Screw Threads and list and use -the formula for thread efficiency.

23) To be able to describe and analyse resistance to rolling.

24) To be able to describe and analsye the friction of Wrapping Connectors.

25) To be able to solve problems like problem 10.1, 10.4, 10.5, 10.7, 10.8.

PART 36t4- INERTIA FORCES

General Objectives - To have a basic understanding of inertia forces and how the effect machine members.

Specific Objectives:

1) To be able to define resultant of forces.

2) To be able to define (a) weight, (b) mass (c) force.

3) To be able to define INERTIA FORCE.

4) To be able to state that the inertia force of any element is dependent upon its mass and its acceleration.

5) To be able to state that a dynamic force analysis takes into account inertia forces.

6) To be able to analyse the inertia forces of a Rigid Body having plane motion.

7) To be able to list and use the following formula

a) $F = -w^2 Z.r\ dm$

b) $T = -I_G * <$

8) To be able to state that the resultant of all the inertia forces of a rigid body is an inertia fo^ce through the center of gravity of magnitude ma^ and an inertia couple of magnitude IQ

9) To be able to analyse the Inertia Forces of a Floating Link.

10) To be able to list and use the formula:

$$h = \frac{l_n o <}{F G}$$

11) To be able to state that the resultant inertia force on a floating link is the single force F which is parallel to AG opposite in direction to AG, and displace a distance -h from AQ. The moment Fh must oppose the angular acceleration of the link.

12) To be able to analyse the Inertia Forces of a link rotating about a fixed center.

13) To be able to state that with a fixed axis of rotatation, the inertia force of the link always passes through a fixed point E on the link, this point is called" the"CENTER OF PERCUSSION" of the link with respect to the fixed axis of rotation "0".

14) To be able to list and use the following formula:

a) $T = 2yj / \underline{h_b + h_e}$

b) $I_G \ll mh_bh_e = mh_bf\ T\hat{}a - hA$

15) To be able to find and use the Transverse and Radial Components of a force.

16) In a four link mechanism to be able to determine (1) the inertia forces of the moving members (2) the torque which must be applied to the driving link (3) the effect of the inertia forces upon the frame, given angular velocity and acceleration of the driving link and mass and moment of inertia of each of the moving links.

17) To be able to do a combined static and inertia force analysis.

18) To be able to discuss, find, and use the KINETICALLY EQUIVALENT SYSTEM for any given system.

19) To be able to solve problems that illustrate the application of the kinetically equivalent system to an engine mechanism.

20) To be able to solve problems like problems 11-1, 11-2, 11-4, in the text.

PART 5 - BALANCING OF MACHINERY

General Objectives - To have a sound understanding of the theories and practical applications of balancing of machinery.

Specific Objectives:

1) To be able to state two causes of vibrations in the frame of a machine.

2) To be able to state the purpose of balancing.

3) To be able to state two types of balance.

4) To be able to define (a) STATIC BALANCE
(b) DYNAMIC BALANCE

5) To be able to list two groups of reactions between the component parts of an engine in motion.

6) To be able to state that the effect of. rotating masses is to produce centrifugal forces or kinetic loads on the shaft to which the masses are connected.

7) To be able to state how a system of rotating masses is balanced.

8) To be able to state the effect of a single rotating mass on its shaft and how it can be balanced.

9) To be able to state the effect of two rotating masses not in the same plane of rotation and state how to balance the system.

10) To be able to state; the effect of several rotating masses in a single transverse plane, and how to balance this system.

11) To be able to state the effect of several rotating masses in different transverse planes and how this system is balanced.

12) To be able to state that (a) the vector sum of all the centrifugal forces must be zero. i.e. $\sum mR\omega^2 = 0$.

b) the vector sum of the moments of all the forces with respect to any arbitrarily chosen reference plance must be zero.

x.e "21 rnRw^2.

13) To be able to balance systems of any number of rotating masses using the general graphical method of balancing i.e. (a) the moment polygon and force polygon (b) the two moment polygons.

14) To be able to reduce masses to a common radius.

15) To be able to use the analytical method of balancing a system of rotating masses.

16) To be able to state the functions of a balancing machine.

17) To be able to define critical speed,

18) To be able to solve problems like 12.1; 12.5; in the text.

PART 6 - VIBRATIONS & CRITICAL SPEEDS IN SHAFTS

General Objectives - To have a sound understanding of vibrations and critical speeds, what they are and what causes them.

Specific Objectives;

1) To be able to state when an external force charges the shape of a body within its elastic limit, internal restoring forces are set up that end to oppose the external force.

2) To be able to define a) Free or natural vibration
b) Damped vibration
c) Forced vibration
d) Resonance
e) Critical speed.

3) To be able to state the chief cause of a) lateral vibrations and (b) Torsional vibrations.

4) To be able to state four methods of eliminating or reducing vibrations.

5) To be able to list the fundamental equation for lateral vibrations of a shaft.

6) To be able to draw the reciprocating harmonic motion of a vibrating particle represented by the projection of the end of a rotating vector.

7) To be able to list and use the formulas:

a) $m \frac{d^2x}{at^*} = -kx$

b) $T = 2Wp$

c) f » 1/T = P/2?,

8) To be able to list and use the formula:

a) x = A cos pt + B sin pt (Displacement)

b) v = -Ap sin pt + Bp cos pt (Velocity)

c) $x = x_0$ cos pt + vo/p sin pt (General solution)

To be able to draw the displacement time curve for equating in objective #8.

To be able to list and use the formulas:

a) $p = \sqrt{\frac{K}{M}}$

b) $f = \frac{1}{2\pi}\sqrt{\frac{K}{M}}$

c) $f = \frac{1}{2\pi}\sqrt{\frac{g}{\Delta ST}}$

To be able to list and use the formulas for lateral vibration due to a single rotating mass.

a) $m(x + e)w^2 = Kw$

b) $X = (K/MW^2>-1$

c) Wc = |

d) Wc - iff

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To be able to determine the critical speed of a shaft given a steel shaft the diameter, length, the location and weight of a disk and the end conditions.

To be able to list the equation for lateral vibration due to several rotating masses.

To be able to solve problems to determine critical speeds using:

a) solution for a shaft with Uniform Section
b) solution for a shaft with nonuniform section
c) solution for shaft with distributed load. .