1 Torsion Problems

1. Define assumed kinematics between the disks.
2. Define the kinematics for no slip contact points (gears, tracks, and cables).
3. Draw a free body diagram (§6) showing all loads and torques acting on each disk, resist the urge to draw loads that do not exist.
4. Shafts can be assumed to be mass-less.
5. The stored potential energy for a shaft is: $V_{k_\theta} = k_\theta \frac{\theta^2}{2}$.
6. Depending on the number of degrees of freedom, you will need to be able to find natural frequencies, or be able to obtain eigenvalues and eigenvectors (review Chapter 3) and obtain the response equations of the system using modal analysis. Note that there may be a problem that requires you to perform eigen analysis (refer to previous exam summary sheets).

2 Planar Problems

1. Define required kinematics (Motion of mass centers, constraints, assumed relative motion, small angle assumptions).
2. Draw a free body diagram for each body (§6).
3. Apply Newtonian principles to each body.
4. Determine what variables are going to be your unknowns.
5. State equations of motion in matrix form.
6. Solve for eigenvalues and eigenvectors if necessary.

3 Beam Problems

1. Be familiar with the stiffness matrices and inertia matrices with masses attached to the ends.
2. Be able to define and apply boundary conditions to obtain the equations of motion and constraint equations.
3. Be able to work problems where the end mass cannot be treated as a thin disk or plate (example problem 5.3 in the text).
4. Be able to draw a free body diagram of disk elements.
5. Know the stiffness for a beam with zero rotation at the end (Equation 1), and for a beam with zero moment at the end (Equation 2). In both of the previous equations E is a given material property, I is area moment of inertia of the beam, and l is the length of the shaft.

$$k_w = \frac{12EI}{l^3} \tag{1}$$

$$k_p = \frac{3EI}{l^3} \tag{2}$$

4 Planar Mechanisms

1. Define reference system.
2. Define kinematic constraints (Chapter 4 material).
3. Define mass centers, and find composite mass centers if necessary.
4. Make sure that the mass centers you find are **shown clearly** in your kinematic diagram. The systems must be drawn in a general configuration.
5. Draw a free body diagram for each independent part of the mechanism. Again, the free body diagram must be drawn when the system is a general configuration. The parts should be arranged in an exploded view format.

6. Apply Newtonian principles.
   - If a body rotates about a point fixed to the ground use: $\sum M_O = I_O\ddot{\theta}$.
   - If the body is attached to a base that is accelerating you must use: $\sum M_O = I_O\ddot{\theta} + m\left(\vec{b}_{OG} \times \vec{a}_O\right)_Z$.
   - If you need to find the support reaction forces for, say, a double pendulum you must use force summations in the X and Y directions.
   - If the body translates and rotates, then sum moments about the center of gravity and sum forces in the X and Y directions.
   - Force summations are always taken with respect to the mass center of the body.
7. Be able to define unknowns; typical unknowns are variables that define the orientation of a body and forces that connect different bodies.
8. Be able to present results in matrix format, which is of the following form: $[A]\vec{X} = \vec{B}$; where A is an $n \times n$ matrix of coefficients for the unknowns (n is the number of unknowns), $\vec{X}$ is a column vector ($n \times 1$ matrix) of the unknowns, and $\vec{B}$ is a column vector of known elements.

5 Mass Moment of Inertia

1. Mass moment of inertia of a particle is defined as: $I = md^2$; where m is the mass of the particle, and d is the distance from the particle to the point where you want the moment of inertia. Essentially a particle itself has no inertia, but when you have a particle on a 'string' it has inertia (think parallel axis theorem).
2. When given the radius of gyration, use the following to get the moment of inertia: $I_P = mk_P^2$; where m is the mass of the body, and k_P is the radius of gyration relative to a defined point P.
3. You still need to remember the following:
   - The mass moment of inertia for a disk, $I_g = \frac{1}{2}mr^2$.
   - The mass moment of inertia for a slender bar, $I_g = \frac{1}{12}ml^2$ (about the center of gravity).
   - How to apply the parallel axis theorem.
   - How to find the mass center of a composite body ($\bar{X}$ and $\bar{Y}$).

6 Free Body Diagrams

1. Define reference system.
2. Draw body in a general configuration (no links aligned with reference axes).
3. Show and label **all** external forces, and moments.
4. Define assumed direction of motion. These will always go from a fixed reference line to a reference on the figure.
5. Lengths must be defined for moment arm relations.

7 Work-Energy Analysis

1. Kinetic energy terms, T, are defined by velocity components only.
2. Potential energty terms, V:
   - Are defined relative to a datum which you must define for gravitational elements.
   - Are never negative for spring elements.
3. You must state the method you use to find equation of motion ($\frac{d}{dQ}$ or $\frac{d}{dt}$).
4. Appropriate kinematic substitutions need to be shown.
5. Be able to state the expression for non-conservative work (see exam 5 summary sheet).