University of Saskatchewan
Department of Physics and Engineering Physics
E.P. 324.3 Winter 1996
Midterm Test #3 April 4, 1996
Instructor: Dr. D. Steele

Time: 75 minutes

Answer all three questions. Calculators and one-page formula sheets may be used. Data you may need are found at the bottom of page 2, and on page 3.

Problem 1 (20 marks)
A homogeneous wire with a mass per unit length of 1.8 kg/m is used to form the figure shown. The wire diameter is much smaller than the dimensions of the figure. Using the parallel-axis theorem if necessary, determine the moment of inertia of the wire figure:
(a) with respect to the *x* axis;
(b) with respect to the *y* axis.
Using the parallel-axis theorem for products of inertia, and the applicable symmetry laws, determine the mass product of inertia:
(c) I_{xy};
(d) I_{xz}.

Problem 2 (20 marks)
The remote manipulator system (RMS) or "Canadarm" shown is used to deploy payloads from the cargo bay of space shuttles. At the instant shown, the whole RMS is rotating at the constant rate $\omega_1 = 0.03$ rad/s about the axis *AB*. At the same time, portion *BCD* rotates as a rigid body at the constant rate $\omega_2 = d\beta/dt = 0.04$ rad/s about an axis through *B* parallel to the *X* axis. Knowing that $\beta = 30^\circ$, determine
(a) the angular acceleration of *BCD*,
(b) the velocity of *D*,
(c) the acceleration of *D*.

Problem 3 (20 marks)

A uniform rod of total mass m is bent into the shape shown and is suspended by a wire attached at its mass center G. The mass moments of inertia and mass products of inertia about the axes shown are: $I_x = 1/6\ ma^2$; $I_y = 2/3\ ma^2$; $I_z = 5/6\ ma^2$; $I_{xy} = 1/4\ ma^2$; $I_{yz} = I_{zx} = 0$. The bent rod is hit at D in a direction perpendicular to the plane containing the rod (in the negative z direction). Denoting the corresponding impulse by $\mathbf{F}\,\Delta t$, determine immediately after the impact

(a) the velocity of the mass center G;

(b) the angular velocity of the rod.

$g = 9.81\ \text{m/s}^2 = 32.2\ \text{ft/s}^2$.

$\mathbf{i} \times \mathbf{j} = \mathbf{k}$ $\quad \mathbf{j} \times \mathbf{k} = \mathbf{i}$ $\quad \mathbf{k} \times \mathbf{i} = \mathbf{j}$

$\mathbf{j} \times \mathbf{i} = -\mathbf{k}$ $\quad \mathbf{k} \times \mathbf{j} = -\mathbf{i}$ $\quad \mathbf{i} \times \mathbf{k} = -\mathbf{j}$