UNIVERSITY OF SASKATCHEWAN
DEPARTMENT OF MECHANICAL ENGINEERING
ME 316.3 – SYSTEM DYNAMICS AND VIBRATIONS
MID-TERM EXAMINATION – OCTOBER 27, 2004

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2 HOURS
CLOSED BOOK, CALCULATORS PERMITTED.
SHOW YOUR WORK. ANSWER ALL QUESTIONS.

FORMULAE:

$$\vec{V}_B = \vec{V}_A + \frac{dr_{B/A}}{dt}\hat{u}_{B/A} + \vec{\omega}_{AB} \times \vec{r}_{B/A}$$

$$\vec{a}_B = \vec{a}_A + \frac{d^2 r_{B/A}}{dt}\vec{u}_{B/A} + 2\vec{\omega}_{AB} \times \frac{dr_{B/A}}{dt}\vec{u}_{B/A}$$
$$+ \vec{\alpha}_{AB} \times \vec{r}_{B/A} + \vec{\omega}_{AB} \times (\vec{\omega}_{AB} \times \vec{r}_{B/A})$$

Question 1 [40]:

Figure 1 (the next page) shows a mechanism. Body 1 is a disk, and it rotates along the ground surface. At the contact point B there is sufficient friction to prevent any slip at it. Body 2 rotates with respect to disk (Body 1) about a pin at the point C. Body 2 and Body 3 can translate relatively. Body 3 rotates with respect to the ground about the point D. Suppose at the instant shown: (1) both the angular velocity (ω) and angular acceleration (α) of the disk are known, (2) the radius (r) of the disk is known, (3) the distance (d) between A and C is known, and (4) the angle (θ) is known. At the instant shown, please determine the following vector quantities:

(a) the relative angular velocity between body 2 and body 3;
(b) the angular velocity of body 3;
(c) the relative angular velocity of body 1 with respect to body 3;
(d) the relative translation velocity between body 2 and body 3; and
(e) the angular acceleration of body 2.

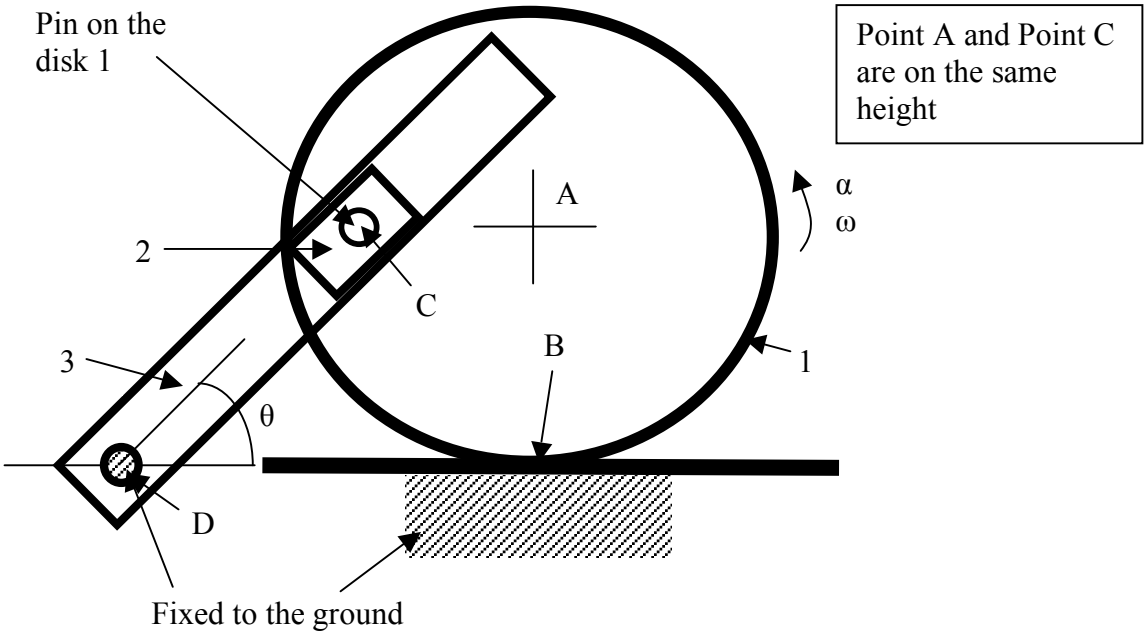

Figure 1

Question 2 [40]:

Figure 2 (the next page) shows a spatial mechanism. The rod AB is connected with a slider at point B by a ball-and-socket joint and connected with a cross-head at point A by a pin (the rod AB can relatively rotate with respect to the cross-head about the pin). The cross-head can perform both relative rotation and relative translation about the vertical shaft AC which is fixed. The pin on the cross-head is perpendicular to both the rod AB and the shaft AC. The slider B only translates along the fixed shaft CD, and its velocity is known. At the instant, point B is on the x-y coordinate plane. At the instant shown, determine:

(a) the translation velocity of the cross-head along the shaft AC.
(b) the angular velocity of rod AB; and
(c) the angular velocity of the cross-head with respect to the shaft AC.

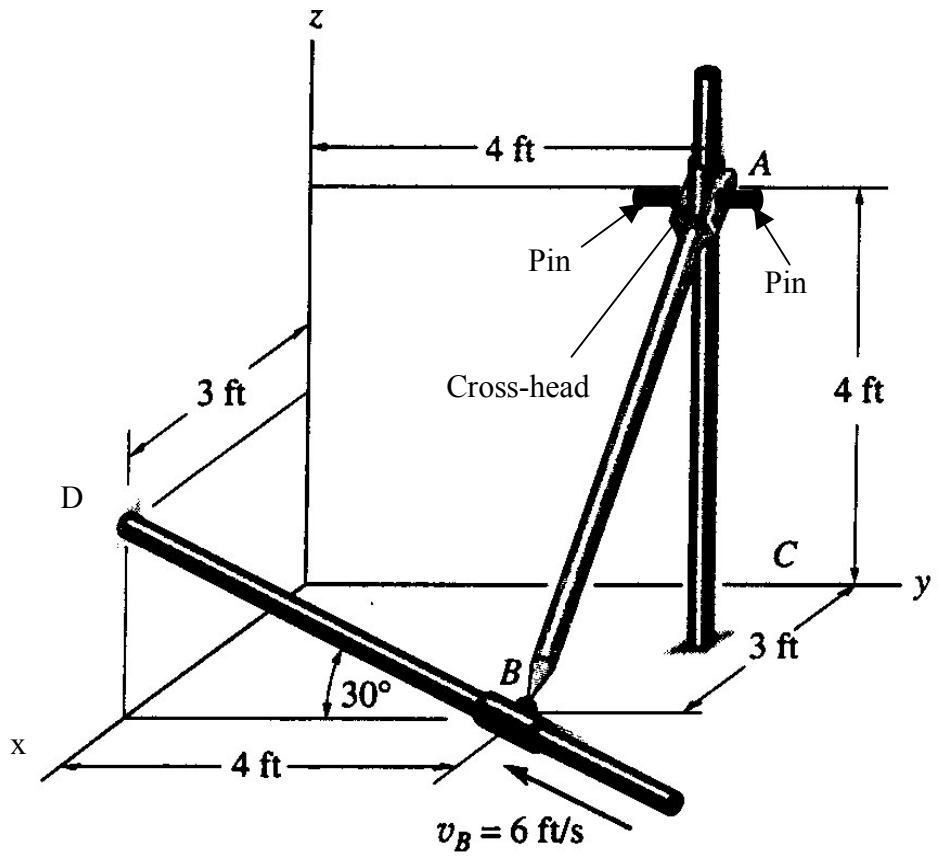

Figure 2

Question 3 [20]:

Figure 3 (the next page) shows a fan. The motion of the fan results from the two consecutive rotations with: one about the Z axis and the other about the Us axis. Suppose: both the angular velocities (ω_Z and ω_S) are known and constant. At the instant, the Us axis is on the y-z coordinate plane. At the instant shown, please determine the following vector quantities:

(f) the absolute angular velocity of the fan (both the direction and the magnitude);
(g) the absolute angular acceleration of the fan (both the direction and the magnitude); and
(h) the expression of the acceleration of any point P on the fan.

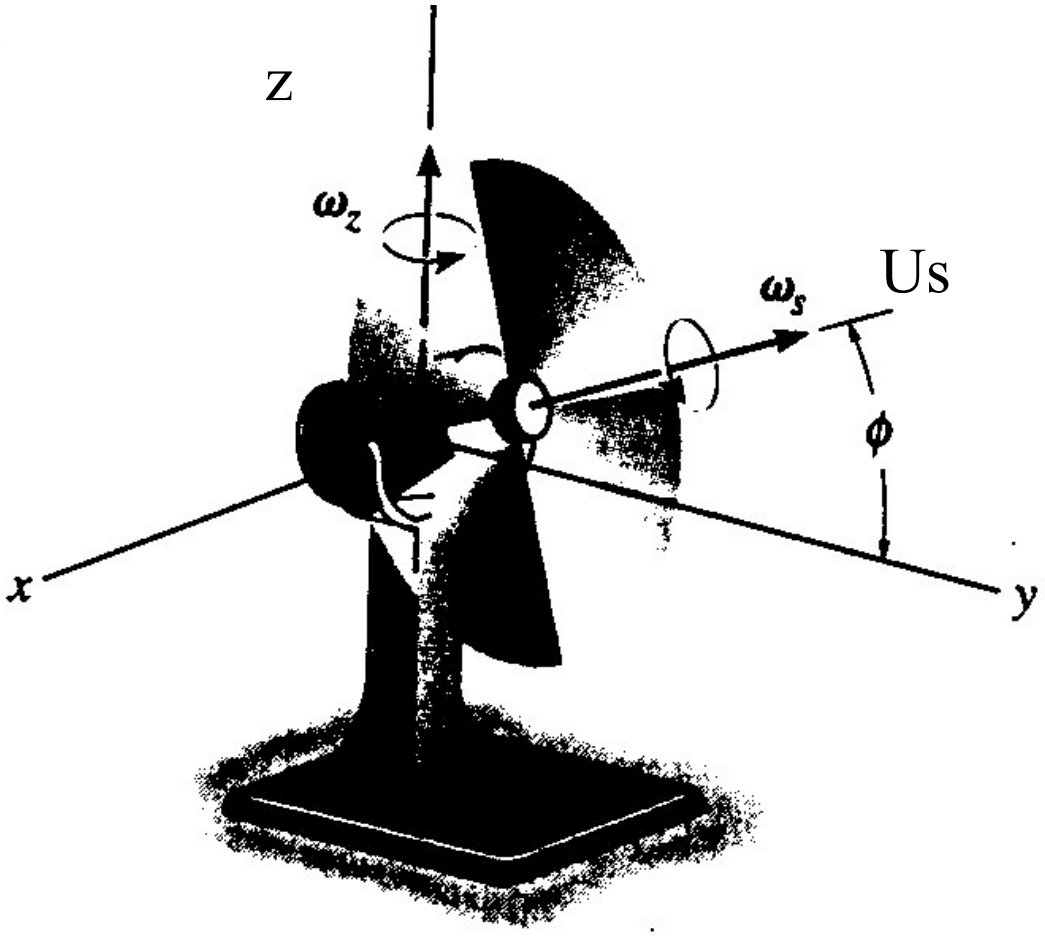

Figure 3

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