CIV100 – MECHANICS – SECTION J

Quiz No.1 – Wednesday, September 29, 2010

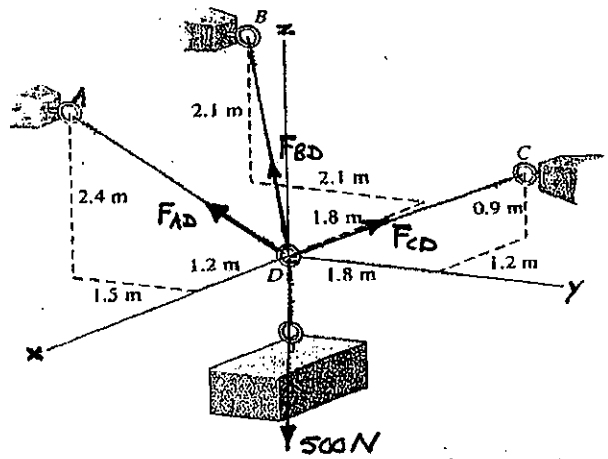
Time Allowed: 1 hour. This is a closed-book test. Questions 1 and 2 are of equal value.

Name (PRINT IN UPPER CASE): PROF. J. A. PACKER

Student No: _____

Circle your calculator type: Casio 260 Sharp 520 Texas Instruments 30

1. A block is supported by a system of cables as shown. The weight of the block is 500 N. Determine the magnitudes of the tension forces in cables AD, BD and CD. (Point C is 0.9 m above the x-y plane).



Length AD $= \sqrt{2.4^2+1.5^2+1.2^2} = 3.074$ m

Length BD $= \sqrt{1.8^2+2.1^2+2.1^2} = 3.473$ m

Length CD $= \sqrt{1.8^2+1.2^2+0.9^2} = 2.343$ m

$F_{AD_x} = \left(\frac{1.2}{3.074}\right)F_{AD}$; $F_{AD_y} = \left(\frac{-1.5}{3.074}\right)F_{AD}$; $F_{AD_z} = \left(\frac{2.4}{3.074}\right)F_{AD}$

$F_{BD_x} = \left(\frac{-1.8}{3.473}\right)F_{BD}$; $F_{BD_y} = \left(\frac{-2.1}{3.473}\right)F_{BD}$; $F_{BD_z} = \left(\frac{2.1}{3.473}\right)F_{BD}$.

$F_{CD_x} = \left(\frac{-1.2}{2.343}\right)F_{CD}$; $F_{CD_y} = \left(\frac{1.8}{2.343}\right)F_{CD}$; $F_{CD_z} = \left(\frac{0.9}{2.343}\right)F_{CD}$.

The resultant of the 3 forces F_{AD}, F_{BD} & F_{CD} must act vertically upwards, and be equal to 500 N.

$\therefore \Sigma F_x = 0 \Rightarrow 0.390F_{AD} - 0.518F_{BD} - 0.512F_{CD} = 0$ ——— (1)

$\Sigma F_y = 0 \Rightarrow -0.488F_{AD} - 0.605F_{BD} + 0.768F_{CD} = 0$ ——— (2)

$\Sigma F_z = 500 \Rightarrow 0.781F_{AD} + 0.605F_{BD} + 0.384F_{CD} = 500$ ——— (3)

} 3 unknowns, 3 simultaneous equations.

From (1), $0.488F_{AD} - 0.648F_{BD} - 0.641F_{CD} = 0$ ——— (4)

} Basically used (1) & (2) to eliminate F_{AD}.

(2) + (4) $\Rightarrow$ $0 - 1.253F_{BD} + 0.127F_{CD} = 0$ ——— (5)

From (3), $0.488F_{AD} + 0.378F_{BD} + 0.240F_{CD} = 312.42$ ——— (6)

} Basically used (2) & (3) to eliminate F_{AD}, .. then got 2 equations with 2 unknowns.

(2) + (6) $\Rightarrow$ $0 - 0.227F_{BD} + 1.008F_{CD} = 312.42$ ——— (7)

From (7), $0 + 1.253F_{BD} - 5.564F_{CD} = -1724.5$ ——— (8)

(5) + (8) $\Rightarrow$ $-5.437F_{CD} = -1724.5$

$\therefore F_{CD} = 317.2$

$\therefore F_{BD} = \frac{-1724.5 + 5.564(317.2)}{1.253} = 32.15$

& $F_{AD} = \frac{0.518(32.15) + 0.512(317.2)}{0.390} = 459.1$

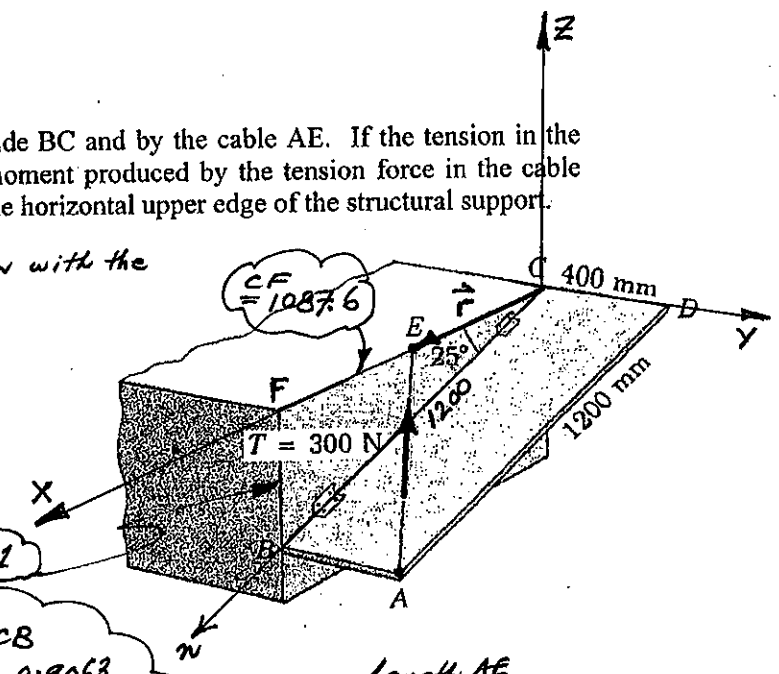
$\therefore$ TENSION FORCES FOR CABLES ARE

AD = 459 N

BD = 32.1 N

CD = 317 N

2. The rectangular plate is supported along its side BC and by the cable AE. If the tension in the cable is 300 N, calculate the magnitude, M, of the moment produced by the tension force in the cable about the hinge axis. Note that E is the mid-point of the horizontal upper edge of the structural support.



Moment about a line, so set up an axis system with the origin on the line, thus at B or C.
∴ Locate X, Y, Z axes as shown @ C.
Then, draw a position vector FROM the origin, TO the line of action of the force, say @ E, as shown. ∴ $\vec{r}$ goes from C to E.

CF = 1087.6

BF = 507.1

Direction Cosines for CB
where $\alpha = \cos 25° = 0.9063$
$\beta = 0$
$\gamma = -\cos 65° = -0.4226$

Length AE
$= \sqrt{(-543.8)^2 + (-400)^2 + (507.1)^2}$
$= 844.3$ mm.

$$\therefore |M_{CB}| = \begin{vmatrix} r_x & r_y & r_z \\ F_x & F_y & F_z \\ \alpha & \beta & \gamma \end{vmatrix}$$

$$= \begin{vmatrix} 600\cos 25° & 0 & 0 \\ \left(\frac{-543.8}{844.3}\right)F & -\left(\frac{400}{844.3}\right)F & \left(\frac{507.1}{844.3}\right)F \\ 0.9063 & 0 & -0.4226 \end{vmatrix}$$

where F = 300 N
& lengths in mm.

$$= \begin{vmatrix} 0.5438 & 0 & 0 \\ -193.2 & -142.1 & +180.2 \\ 0.9063 & 0 & -0.4226 \end{vmatrix}$$ N.m.

$= +0.5438\,(142.1)(0.4226) = 32.66$ (C → B)

$\therefore$ **$|M| = 32.7$ N.m**