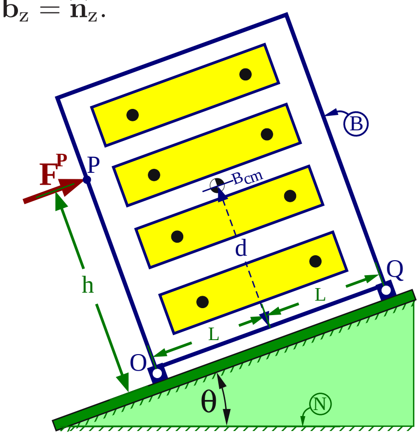
4.12 FE/EIT Review – Bureau sliding on smooth inclined plane (2D analysis, frictionless).

A rigid uniform-density bureau B is in contact with a **smooth** inclined plane at points O and Q of B. A force of magnitude F^P is applied at point P of B (the force is directed up the inclined plane).

Right-handed orthogonal unit vectors $\hat{\mathbf{n}}_x$, $\hat{\mathbf{n}}_y$, $\hat{\mathbf{n}}_z$ and $\hat{\mathbf{b}}_x$, $\hat{\mathbf{b}}_y$, $\hat{\mathbf{b}}_z$ are directed with $\hat{\mathbf{n}}_x$ horizontally-right, $\hat{\mathbf{n}}_y$ vertically-upward, $\hat{\mathbf{b}}_x$ from O to Q, $\hat{\mathbf{b}}_y$ from O to P, and $\hat{\mathbf{b}}_z = \hat{\mathbf{n}}_z$.

Description	Symbol
Angle from $\hat{\mathbf{n}}_x$ to $\hat{\mathbf{b}}_x$ with $+\hat{\mathbf{n}}_z$ sense	θ
Mass of bureau	m
Earth's gravitational acceleration	g
Half-width of bureau	L
Distance between points O and P	h
Distance between B_{cm} and line $\overline{OQ}$	d
Measure of force on B from person	F^P
Measure of normal force on O from inclined plane	F_y^O
Measure of normal force on Q from inclined plane	F_y^Q

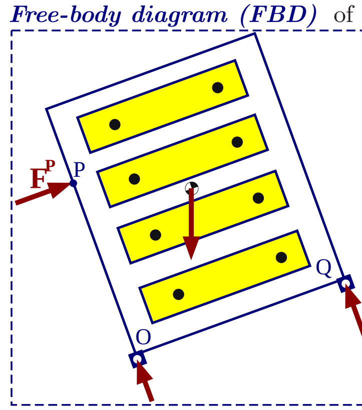


- **Draw** a ***free-body diagram (FBD)*** of B.
- **Draw** $\hat{\mathbf{b}}_x$, $\hat{\mathbf{b}}_y$, $\hat{\mathbf{b}}_z$ and $\hat{\mathbf{n}}_x$, $\hat{\mathbf{n}}_y$, $\hat{\mathbf{n}}_z$. Form the ${}^bR^n$ rotation table.

Result:

${}^bR^n$	$\hat{\mathbf{n}}_x$	$\hat{\mathbf{n}}_y$	$\hat{\mathbf{n}}_z$
$\hat{\mathbf{b}}_x$	$\cos(\theta)$	$\sin(\theta)$	0
$\hat{\mathbf{b}}_y$	$-\sin(\theta)$	$\cos(\theta)$	0
$\hat{\mathbf{b}}_z$	0	0	1

Free-body diagram (FBD) of B



- Assuming B slides without friction at **constant** speed, solve for F^P, F_y^O, F_y^Q, by setting $\vec{\mathbf{F}}^B$ (resultant force on B) and $\vec{\mathbf{M}}^{B/O}$ (moment of forces on B about O) to $\vec{\mathbf{0}}$ (***static equilibrium***).

Related: Hw 16.8, 16.9

Result: (in terms of θ, m, g, L, h, d).

$$F^P = m\,g\,\sin(\theta) \qquad F_y^O = 0.5\,m\,g\left[\cos(\theta) - \frac{h-d}{L}\sin(\theta)\right] \qquad F_y^Q = 0.5\,m\,g\left[\cos(\theta) + \frac{h-d}{L}\sin(\theta)\right]$$

Solution at **www.MotionGenesis.com** ⇒ **Get Started** ⇒ **Simple statics.**