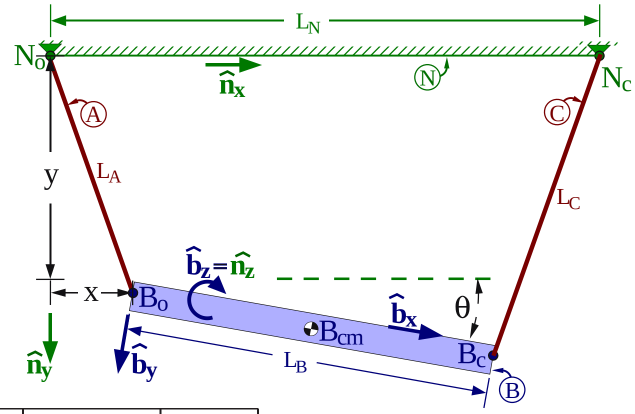
8.13 Kinematics of a swinging beam - with constant length cables. (Section 10.1)

Consider the swinging beam (construction hoist) system shown right and described in Homework 4.15.

Cables A and C are modeled as straight and inextensible (**constant length**).

Points N_o, N_C, B_o, B_C are all in the same vertical plane and the uniform rigid beam B's motion is restricted to that plane (which is perpendicular to $\widehat{\mathbf{n}}_z = \widehat{\mathbf{b}}_z$).



Description	Symbol	Type	Value
Distance between N_o and N_C	L_N	Constant	6 m
Distance between B_o and B_C	L_B	Constant	4 m
Length of cable A	L_A	Constant	2.7 m
Length of cable C	L_C	Constant	3.7 m
$\widehat{\mathbf{n}}_x$ measure of B_o's position vector from N_o	x	Variable	varies
$\widehat{\mathbf{n}}_y$ measure of B_o's position vector from N_o	y	Variable	varies
Angle from $\widehat{\mathbf{n}}_x$ to $\widehat{\mathbf{b}}_x$ with $^+\widehat{\mathbf{n}}_z$ sense	θ	Variable	varies

(a) **Efficiently** express the following quantities in terms of $\widehat{\mathbf{n}}_x, \widehat{\mathbf{n}}_y, \widehat{\mathbf{n}}_z$ and/or $\widehat{\mathbf{b}}_x, \widehat{\mathbf{b}}_y, \widehat{\mathbf{b}}_z$.

B's angular velocity in N	${}^N\vec{\boldsymbol{\omega}}^B$	$= \square$
B's angular acceleration in N	${}^N\vec{\boldsymbol{\alpha}}^B$	$= \square$
B_{cm}'s position vector from N_o	$\vec{\mathbf{r}}^{B_{cm}/N_o}$	$= \square\,\widehat{\mathbf{n}}_x + \square\,\widehat{\mathbf{n}}_y + 0.5\,\square\,\widehat{\mathbf{b}}_x$
B_{cm}'s velocity in N	${}^N\vec{\mathbf{v}}^{B_{cm}}$	$= \square\,\widehat{\mathbf{n}}_x + \square\,\widehat{\mathbf{n}}_y + \square\,\widehat{\mathbf{b}}_y$
B_{cm}'s acceleration in N	${}^N\vec{\mathbf{a}}^{B_{cm}}$	$= \square\,\widehat{\mathbf{n}}_x + \square\,\widehat{\mathbf{n}}_y + \square\,\widehat{\mathbf{b}}_y - \square\,\widehat{\mathbf{b}}_x$

(b) Aerodynamic damping is modeled as depending on the square of ${}^N\vec{\mathbf{v}}^{B_{cm}}$, denoted here as $\vec{\mathbf{v}}^{\,2}$. **Efficiently** calculate $\vec{\mathbf{v}}^{\,2}$ in terms of symbols in the table and their time-derivatives.
Result: $\vec{\mathbf{v}}^{\,2} = \square$

(c) As shown in Homework 4.15, there are geometrical (kinematical) relationships between x, y, and θ. Given numerical values for L_N, L_B, L_A, L_C, and x, and an understanding of how construction hoists on cables work on Earth, its possible to uniquely determine y and θ using:

Just mathematics/Math and physical intuition/Neither (circle one of the choices)

(d) † Calculate $\vec{\mathbf{v}}^{\,2}$ (2⁺ significant digits) when $x = 1$ m and $\dot{x} = 0.4\ \frac{\text{m}}{\text{s}}$.
Result: $\vec{\mathbf{v}}^{\,2} = 0.134\ \frac{\text{m}^2}{\text{s}^2}$

Hint: Intermediate results are $y = 2.508$ m, $\theta = 0.2565$ rad $= 14.7°$, $\dot{y} = -0.1595\ \frac{\text{m}}{\text{s}}$, $\dot{\theta} = 0.06863\ \frac{\text{rad}}{\text{sec}}$.
Hint: Refer to Homework 4.15. Consider using a computational tool, e.g., MotionGenesis.
Stumped? Student/instructor scripts at www.MotionGenesis.com ⇒ Textbooks ⇒ Resources ⇒ Swinging beam.