8.1 ♣ Notation, words, pictures for position, velocity, and acceleration. (Sections 3.1 and 10.1)

Complete each blank with a word: point | reference frame | position | velocity | acceleration

$\vec{\mathbf{r}}^{Q/P}$ is point Q's ____ vector from ____ P.	${}^N\vec{\mathbf{v}}^Q$ is point Q's ____ in ____ N.	${}^N\vec{\mathbf{a}}^Q$ is point Q's ____ in ____ N.
Draw P, Q, and $\vec{\mathbf{r}}^{Q/P}$.	**Draw** Q and N.	

8.2 ♣ What is a point and a particle? (Section 3.1)

To visualize center of mass, draw a doughnut.

Statement	True or False
A point has all the attributes of a particle.	**True/False**
A particle has all the attributes of a point.	**True/False**
A point with mass (massive point) is a particle.	**True/False**
The center of mass of a rigid body is a point.	**True/False**
The center of mass of a rigid body is a particle.	**True/False**

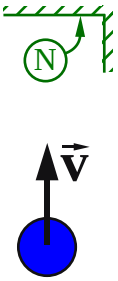
8.3 ♣ Concept: What objects have a unique velocity/acceleration? (Section 10.1)

The velocity $\vec{\mathbf{v}}$ of some object S relative to Earth is to be determined.
This object S could be a (circle ***all*** objects that have an ***unambiguously*** defined velocity $\vec{\mathbf{v}}$):

Real number	Line	Set of points	Center of a circle
Vector	Triangle	Reference frame	Mass center of set of particles
Matrix	Point	Rigid body	Mass center of a rigid body
3D orthogonal basis	Particle	Flexible body	System of particles and bodies

Repeat for the acceleration $\vec{\mathbf{a}}$ of some object S relative to Earth box appropriate objects.

8.4 ♣ Concept: Velocity, acceleration, and differentiation. (Sections 1.6.1 and 10.1)



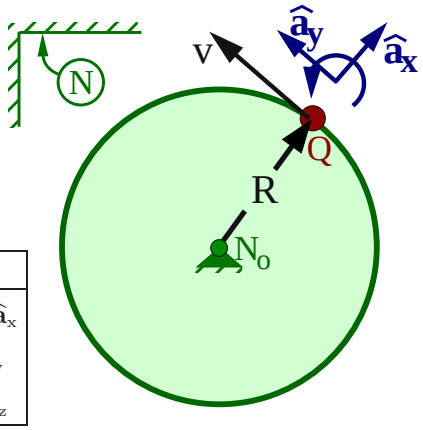
A baseball (particle) is thrown straight upward on Earth (a Newtonian reference frame N). Knowing the baseball's velocity $\vec{\mathbf{v}} = \vec{\mathbf{0}}$ when the ball reaches maximum height and Earth's gravitational acceleration constant $g \approx 9.8 \frac{\text{m}}{\text{s}^2}$, decide if the following statement about $\vec{\mathbf{a}}$ (the ball's acceleration in N) is true. If false, box the incorrect part of the statement.

$$\vec{\mathbf{a}} \triangleq \frac{{}^N d\vec{\mathbf{v}}}{dt} = \frac{{}^N d\,(\vec{\mathbf{0}})}{dt} = \frac{d\,\vec{\mathbf{0}}}{dt} = \vec{\mathbf{0}} \qquad \textbf{True/False}$$

Explain:

8.5 Calculating centripetal acceleration in 2D. (Section 10.1)

The following figure shows a point Q moving on a circle.
The circle is centered at N_o and fixed in a reference frame N.



A right-handed orthogonal unitary basis A is oriented with:

- $\hat{\mathbf{a}}_x$ directed from N_o to Q
- $\hat{\mathbf{a}}_z$ outward normal to the circle/paper.

Description	Symbol & type		Related
Radius of circle (distance between N_o and Q)	R	Constant	$\vec{\mathbf{r}}^{\,Q/N_o} = R\,\hat{\mathbf{a}}_x$
$\hat{\mathbf{a}}_y$ measure of Q's velocity in N	v	Variable	${}^N\vec{\mathbf{v}}^{\,Q} = v\,\hat{\mathbf{a}}_y$
$\hat{\mathbf{a}}_z$ measure of A's angular velocity in N	ω	Variable	${}^N\vec{\boldsymbol{\omega}}^{\,A} = w\,\hat{\mathbf{a}}_z$

(a) Write the definition of Q's velocity in N. **Show each step** to write v in terms of ω.
Result: (Also rearrange to solve for ω in terms of v.)

$${}^N\vec{\mathbf{v}}^{\,Q} \underset{(10.1)}{\triangleq} \qquad = v\,\hat{\mathbf{a}}_x \qquad \underset{\text{Show work}}{\Rightarrow} \qquad v = \qquad \underset{\text{Rearrange}}{\Rightarrow} \qquad \omega =$$

(b) Calculate Q's acceleration in N, first in terms of R, ω, $\dot{\omega}$, then in terms of R, v, $\dot{v}$.
Result: (expressed in terms of $\hat{\mathbf{a}}_x$, $\hat{\mathbf{a}}_y$, $\hat{\mathbf{a}}_z$).

$${}^N\vec{\mathbf{a}}^{\,Q} = \underbrace{\qquad\qquad}_{\text{In terms of } R,\,\omega,\,\dot{\omega}} = \qquad\qquad$$

(c) Consider the situation when Q moves with ***constant*** speed on the circle (i.e., v is constant).
Express ${}^N\vec{\mathbf{a}}^{\,Q}$ in terms of $\vec{\boldsymbol{\omega}}^2$ ($\vec{\boldsymbol{\omega}}$ is A's angular velocity in N) and $\vec{\mathbf{r}}$ (Q's position vector from N_o).
Result: ${}^N\vec{\mathbf{a}}^{\,Q} = -\vec{\boldsymbol{\omega}}^2\,\vec{\mathbf{r}}$

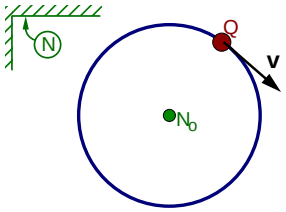
Hint: Rearrange your previous result or use equation (10.3) and eliminate cross-products via a vector identity.

(d) The direction of Q's centripetal acceleration in N is (choose one):
From N_o to Q / From Q to N_o / Tangent to the circle / Outward normal to circle/ Other.

(e) As described in Section 10.10:
The literal meaning of the word "centripetal" is "**center-** ".
The literal meaning of the word "centrifugal" is "**center-** ".

8.6 ♣ Velocity and acceleration concepts: What does "constant" mean? (Section 7.4 and Hw 8.5)

The figure to the right shows a point Q moving with **constant speed** on a circle centered at N_o and fixed in a reference frame N. The following questions refer to $\vec{\mathbf{v}}$ (Q's velocity in N) and $\vec{\mathbf{a}}$ (Q's acceleration in N).



The magnitude of $\vec{\mathbf{a}}$ is constant	**True/False**
$\vec{\mathbf{a}}$ is constant in N	**True/False**
$\vec{\mathbf{v}}$ is constant in N	**True/False**