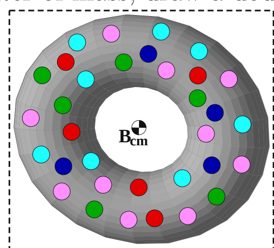
8.1 ♣ Notation, words, pictures for position, velocity, and acceleration. (Sections 3.1 and 10.1)

Description (**fill-in words**):	Description (**fill-in words**):	Description (**fill-in words**):
$\vec{\mathbf{r}}^{\,Q/P}$ is point Q's position vector from point P.	${}^{N}\vec{\mathbf{v}}^{Q}$ is point Q's velocity in reference frame N.	${}^{N}\vec{\mathbf{a}}^{Q}$ is point Q's acceleration in reference frame 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**



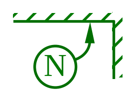
8.3 ♣ Concept: What objects have a unique velocity/acceleration? (Section 10.1)

${}^{N}\vec{\mathbf{v}}^{S}$, the velocity of an object S in a reference frame N is to be determined.
In general and **without ambiguity**, S should be a (circle ***all*** appropriate objects):

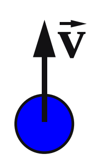
Vector	**Point**	Reference Frame	**Center of mass of a set of particles**
Matrix	Set of Points	Rigid Body	**Center of mass of a rigid body**
Center of a circle	**Particle**	Flexible Body	Set of flexible bodies
Orthogonal unit basis	Set of Particles	Set of Rigid bodies	System of particles and bodies

Repeat for ${}^{N}\vec{\mathbf{a}}^{S}$, the acceleration of an object S in a reference frame N box appropriate objects.

8.4 ♣ Concept: Velocity, acceleration, and differentiation. (Sections 1.7.1 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.



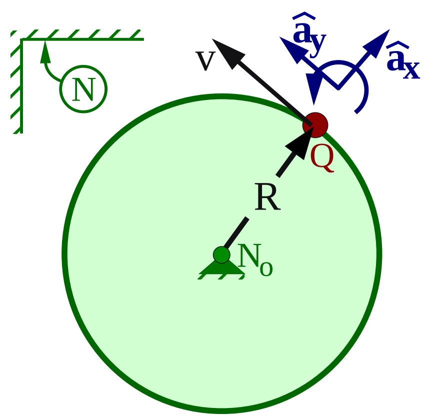
$$\vec{\mathbf{a}} \triangleq \boxed{\frac{{}^{N}d\vec{\mathbf{v}}}{dt} = \frac{{}^{N}d\,(\vec{\mathbf{0}})}{dt}} = \frac{d\,\vec{\mathbf{0}}}{dt} = \vec{\mathbf{0}}$$

True/**False**

Explain: It is incorrect to time-differentiate the instantaneous value $\vec{\mathbf{v}} = \vec{\mathbf{0}}$.
Time-differentiation must occur over dt (dt is defined as a non-zero interval of t, not at an *instant*).

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
Radius of circle (distance between N_o and Q)	R	Constant
$\hat{\mathbf{a}}_y$ measure of Q's velocity in N	v	Variable
$\hat{\mathbf{a}}_z$ measure of A's angular velocity in N	ω	Variable

(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.)

$$ {}^{N}\vec{\mathbf{v}}^{Q} \underset{(10.1)}{\triangleq} \frac{{}^{N}d\,\vec{\mathbf{r}}^{\,Q/N_o}}{dt} \qquad v = \omega\, R \quad \underset{\text{Rearrange}}{\Rightarrow} \quad \omega = \frac{v}{R} $$

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

$$ {}^{N}\vec{\mathbf{a}}^{Q} = -\omega^2 R\,\hat{\mathbf{a}}_x + \dot{\omega}\, R\,\hat{\mathbf{a}}_y = -\frac{v^2}{R}\,\hat{\mathbf{a}}_x + \dot{v}\,\hat{\mathbf{a}}_y $$

(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: ${}^{N}\vec{\mathbf{a}}^{Q} = -\vec{\boldsymbol{\omega}}^2\,\vec{\mathbf{r}}$

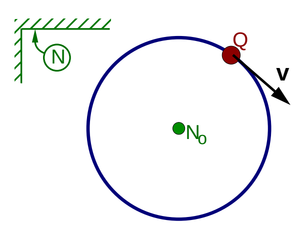
Hint: Rearrange your previous result or use equation (10.3) and eliminate cross-products via the vector identity $\vec{\mathbf{a}} \times (\vec{\mathbf{b}} \times \vec{\mathbf{c}}) = \vec{\mathbf{b}}\,(\vec{\mathbf{a}} \cdot \vec{\mathbf{c}}) - \vec{\mathbf{c}}\,(\vec{\mathbf{a}} \cdot \vec{\mathbf{b}})$.

(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-seeking".
The literal meaning of the word "centrifugal" is "center-fleeing".

8.6 ♣ Velocity and acceleration concepts: What does "constant" mean? **(Section 6.4 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**