



Show work – except for ♣ fill-in-blanks-problems.

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

Description (fill-in words): $\vec{r}^{Q/P}$ is point <input type="text"/> position vector from <input type="text"/> P .	Description (fill-in words): ${}^N\vec{v}^Q$ is <input type="text"/> <input type="text"/> velocity in reference frame <input type="text"/> .	Description (fill-in words): ${}^N\vec{a}^Q$ is point Q 's <input type="text"/> in <input type="text"/> .
Draw P , Q , and $\vec{r}^{Q/P}$. 	Draw Q and N . 	

7.2 ♣ 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



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

${}^N\vec{v}^S$, 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):

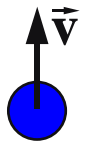
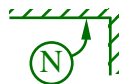
Vector	Point	Reference Frame	Center of mass of a set of particles
Matrix	Set of Points	Rigid Body	Center of mass of a rigid body
Center of a circle	Particle	Flexible Body	Set of flexible bodies
Orthogonal unit basis	Set of Particles	Set of Rigid bodies	System of particles and bodies

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

7.4 ♣ 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 $\vec{v} = \vec{0}$ when the ball reaches maximum height and Earth's gravitational acceleration constant $g \approx 9.8 \frac{m}{s^2}$, decide if the following statement about \vec{a} (the ball's acceleration in N) is true. If false, box the incorrect part of the statement.

$$\vec{a} \triangleq \frac{d\vec{v}}{dt} = \frac{d(\vec{0})}{dt} = \frac{d\vec{0}}{dt} = \vec{0} \quad \text{True/False}$$



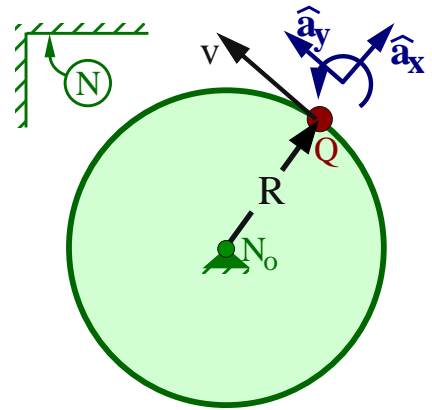
Explain:

7.5 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 .)

$${}^N\vec{v}^Q \triangleq \text{[yellow box]} \quad v = \text{[yellow box]} \quad \Rightarrow_{\text{Rearrange}} \quad \omega = \text{[yellow box]} \quad (10.1)$$

- (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 $\hat{\mathbf{a}}_x$, $\hat{\mathbf{a}}_y$, $\hat{\mathbf{a}}_z$).

$${}^N\vec{\mathbf{a}}^Q = \text{[yellow box]} \hat{\mathbf{a}}_x + \text{[yellow box]} \hat{\mathbf{a}}_y = \text{[yellow box]} \hat{\mathbf{a}}_x + \text{[yellow box]} \hat{\mathbf{a}}_y$$

- (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 $\vec{\omega}^2$ ($\vec{\omega}$ is A 's angular velocity in N) and $\vec{\mathbf{r}}$ (Q 's position vector from N_o).

Result: ${}^N\vec{\mathbf{a}}^Q = \text{[yellow box]}$ 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.

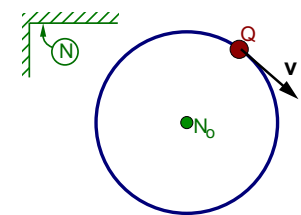
- (e) As described in Section 10.10:

The literal meaning of the word "centripetal" is "center- ".

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

7.6 ♣ Velocity and acceleration concepts: What does "constant" mean? (Section 6.4 and Hw 7.5)

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{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{v} is constant in N **True/False**