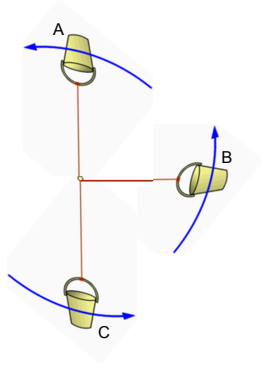
L11 – Phys20 – Vertical Systems

Agenda:

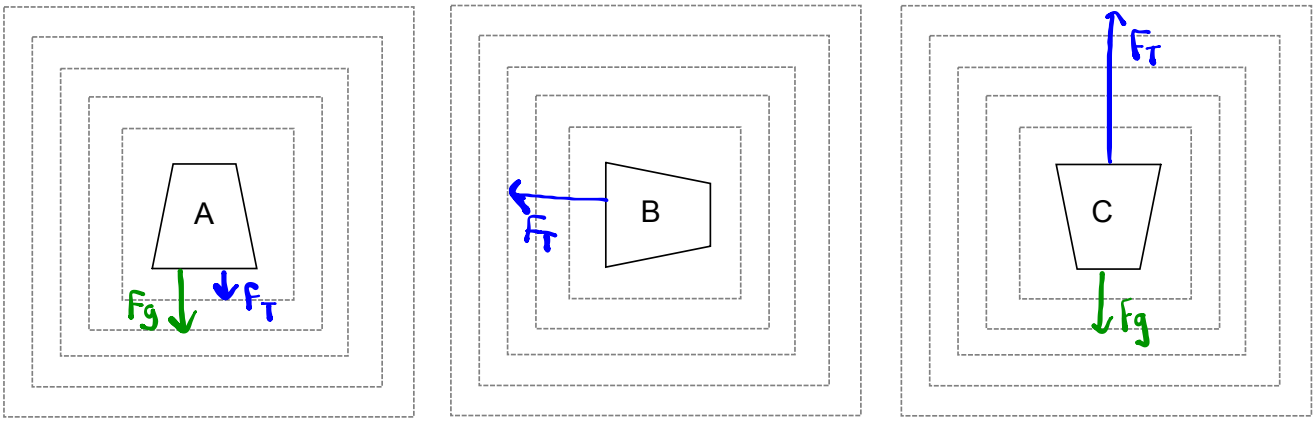
- Attendance
- Formative Quiz: Horizontal Systems
- Lesson: Vertical Systems
- Practice: Pg 264 #1,3
  Pg 262 #1,2

Vertical Systems



1. Draw a Free-Body diagram for the bucket in each position.
2. What force(s) are acting as the Centripetal Force in each position?
3. When does the rope have the most tension?

NOTE: For the diagrams below, assume that F_c = 3 units, and F_g = 2 units



$F_C = F_g + F_T$
$= 2 + 1$
$= 3$ units

$F_C = F_T$
$= 3$ units

$F_C = F_T + F_g$
$= 5 + (-2)$
$= 3$ units

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Thought Problem

Car moving a different speeds through a loop.

$F_C = \frac{mv^2}{r}$

Fast Speed

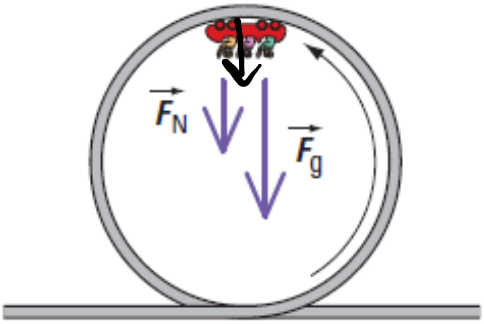
F_c = 1500 N
F_g = 1000 N

What is the F_N?

$F_C = F_g + F_N$

$+1500 = +1000 + F_N$

$F_N = +500\,N$

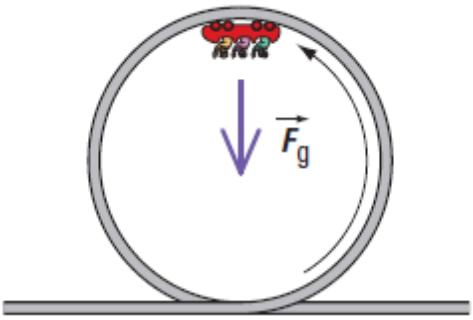


Medium Speed

F_c = 1000 N
F_g = 1000 N

What is the F_N?

$F_N = 0\,N$



Slow Speed

F_c = 800 N
F_g = 1000 N

What is the F_N?

$F_C = F_g + F_N$

$800 = 1000 + F_N$

$F_N = -200\,N$ ✗

The minimum speed needed to complete circular motion in the vertical plane is when the $F_c = F_g$

At top

$F_c = F_g$ ($+0\,N$ of F_N)

Min speed

Video Example:

Q1: What is the minimum speed Danger Aaron needs at the top of loop in order to make it around the loop if the loop has a radius of 2 m.

At the top, $F_c = F_g + F_N$ (0 at min speed)

$$\frac{mv^2}{r} = mg$$

$$\frac{v^2}{2} = 9.81$$

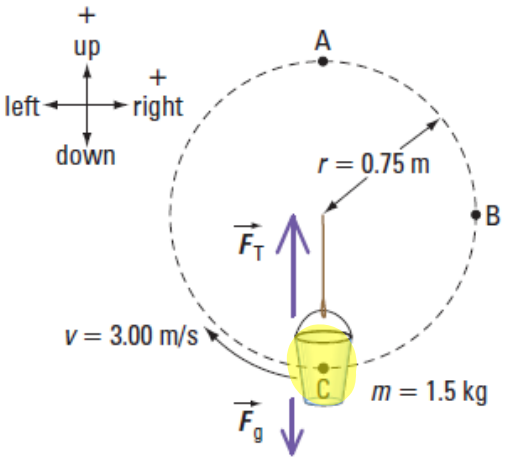
$$v^2 = 19.62$$

$$v = 4.43 \text{ m/s}$$

$$\approx 15.9 \text{ kph}$$

A different example. No calculations needed for this one.

Q2: A bucket of water with a mass of 1.5kg is spun in a vertical circle on a rope. The radius of the circle is 0.75m and the speed of the bucket is 3.00 m/s. What is the tension of the rope in position C, as shown in the figure?



$m = 1.5kg$
$r = 0.75m$
$v = 3 m/s$

$F_c = F_g + F_T$

$F_c = \frac{mv^2}{r} = \frac{(1.5)(3)^2}{0.75} = 18N$

$F_g = mg = (1.5)(9.81) = 14.715N$

At C

$F_c = F_T + F_g$

$+18 = F_T + (-14.715)$

$+14.715 \quad +14.715$

$32.715N = F_T$

Q3: What is the minumum speed requried for the bucket to successfully complete the loop?

At top $F_c = F_g + F_T$ ($F_T \to 0$)

$\frac{mv^2}{r} = mg$

$\frac{v^2}{0.75} = 9.81$

$v^2 = 7.3575$

$v \approx 2.71 m/s$

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Practice:

Pg 264 #1, 3

Pg 262 #1, 2

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