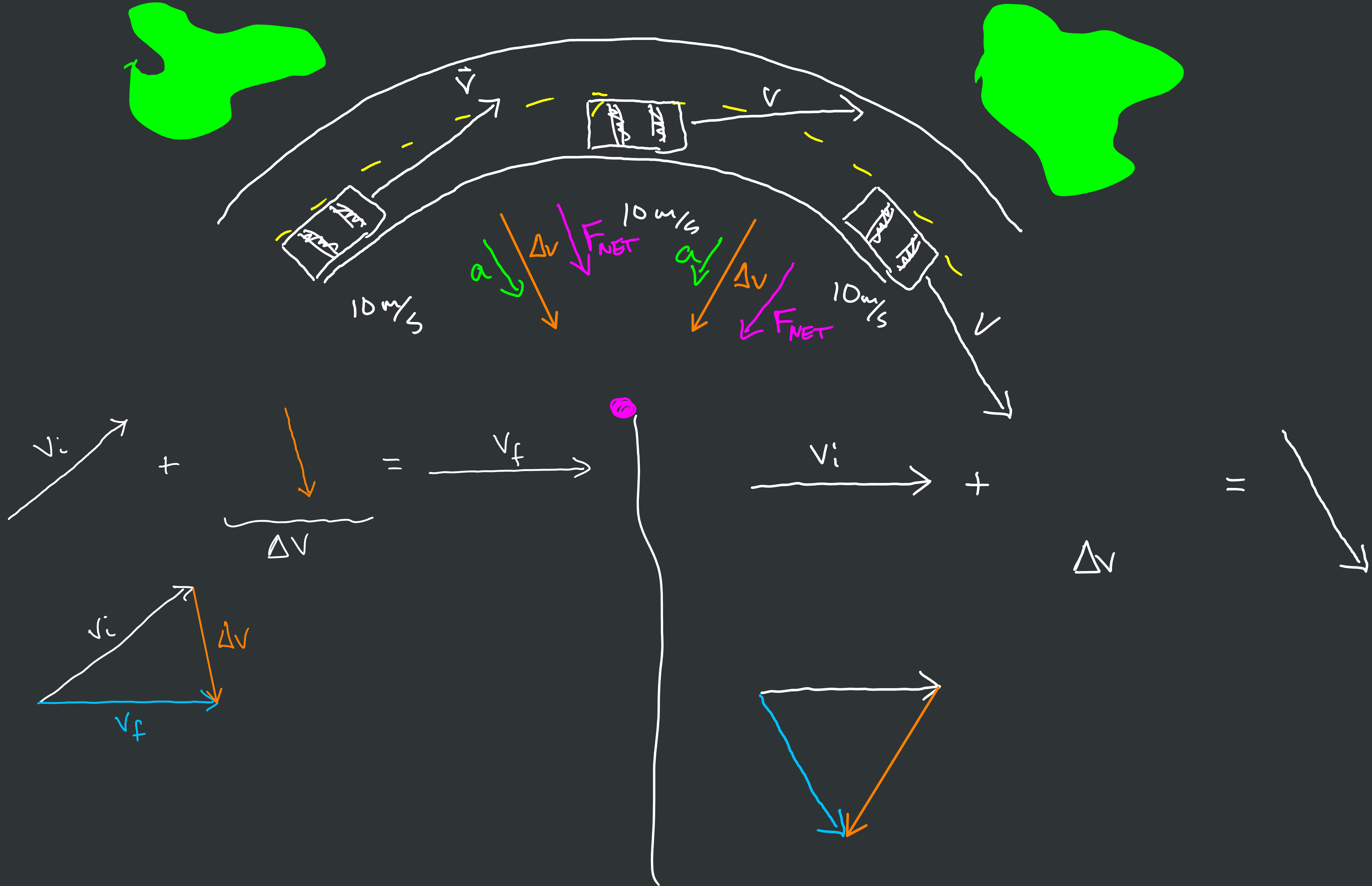
Chapter 5 - Circular Motion and Gravity

velocity - speed and direction

↳ change in velocity - Δv

$$\underset{\vec{V}_i}{\xrightarrow{10\ m/s}} + \underset{\Delta v}{\xrightarrow{15\ m/s}} = \underset{V_f}{\xrightarrow{25\ m/s}}$$

$$\underset{V_i}{\xrightarrow{25\ m/s}} + \underset{\Delta v}{\xleftarrow{22\ m/s}} = \underset{V_f}{\xrightarrow{3\ m/s}}$$

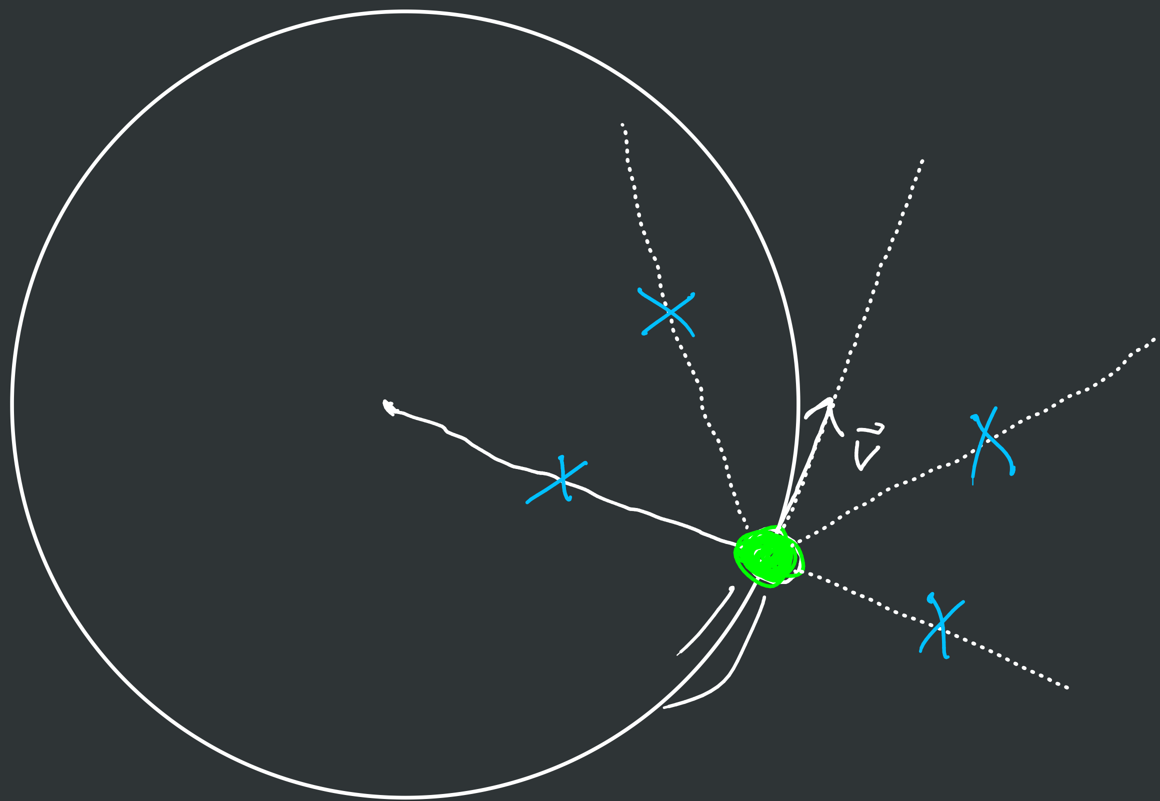


$\vec{v}$
v
10 m/s
10 m/s
10 m/s
a
Δv
F_{NET}
a
Δv
F_{NET}
v
v_i
+
Δv
=
v_f
v_i
+
Δv
=
v_i
Δv
v_f

radial (centripetal) acceleration $= a_r = \dfrac{(\text{speed around the circle})^2}{\text{radius}}$

$$\boxed{a_r = \frac{v^2}{r}}$$

$$F_{NET} = ma \quad \hookrightarrow \quad F_{NET} = \frac{mv^2}{r}$$



$m = 0.1\,kg$

$r = 1\,m$

$V = \dfrac{2\pi r}{t} = 12.56\,m/s$

$t \approx 0.5\,s$

$a_r = \dfrac{(12.56\,m/s)^2}{1\,m} = 158\,m/s^2$

$F_{NET} = m \cdot a = 0.1\,kg \cdot 158\,m/s^2$

$F_{NET} = 15.8\,N$

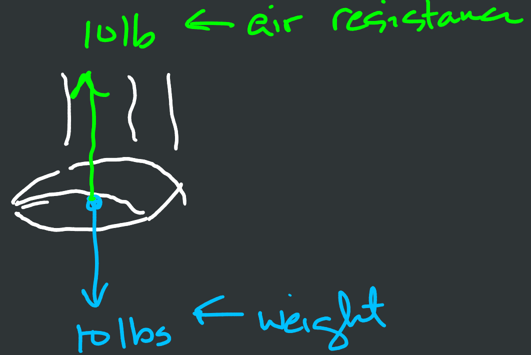
measure of force

Your weight is 120 lb. Suppose you are standing on a scale in an elevator moving up with a constant speed of 4 m/s. What would be the reading on the scale?

A. 480 lb
B. 120 lb
C. 70 lb
D. 30 lb
E. 0

A 10-pound sack of potatoes falls from an airplane. As the velocity of the falling sack increases, so does the air resistance on it. When the air resistance equals 10 pounds, the acceleration of the sack will be

A. 100 ft/s^2
B. 9.8 m/s.
C. 9.8 m/s^2.
D. zero.



An object undergoes uniform circular motion. Which pair of vectors is perpendicular?

A. Its centripetal acceleration and the centripetal force
B. Its centripetal acceleration and velocity vectors
C. All three vectors are mutually perpendicular: centripetal acceleration, centripetal force, and velocity.

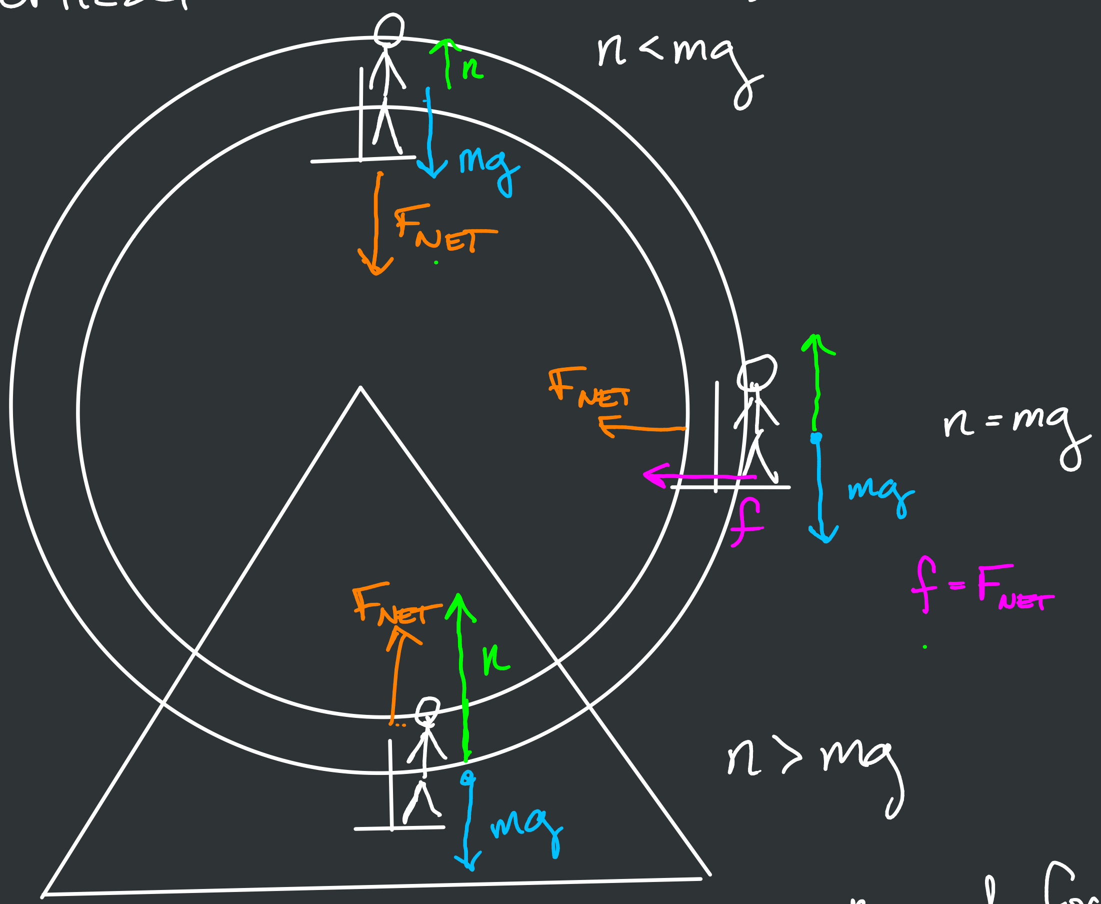
vectors

- displacement
- velocity
- acceleration
- force

not-vectors (scalars)

- mass
- temperature
- speed
- volume

Vertical Circular Paths



$r = 10\,m$

$v = 4\,m/s$

$m = 70\,kg$

$a_r = \frac{v^2}{r} = \frac{(4\,m/s)^2}{10\,m} = 1.6\,m/s^2$

$F_{NET} = ma_c = 70\,kg \cdot 1.6\,m/s^2$

$F_{NET} = 112\,N$

$F_g = m \cdot g = 70\,kg \cdot (10\,m/s^2)$

$F_g = 700\,N$

normal force at the top:

$F_{NET} = F_g + \text{normal}$

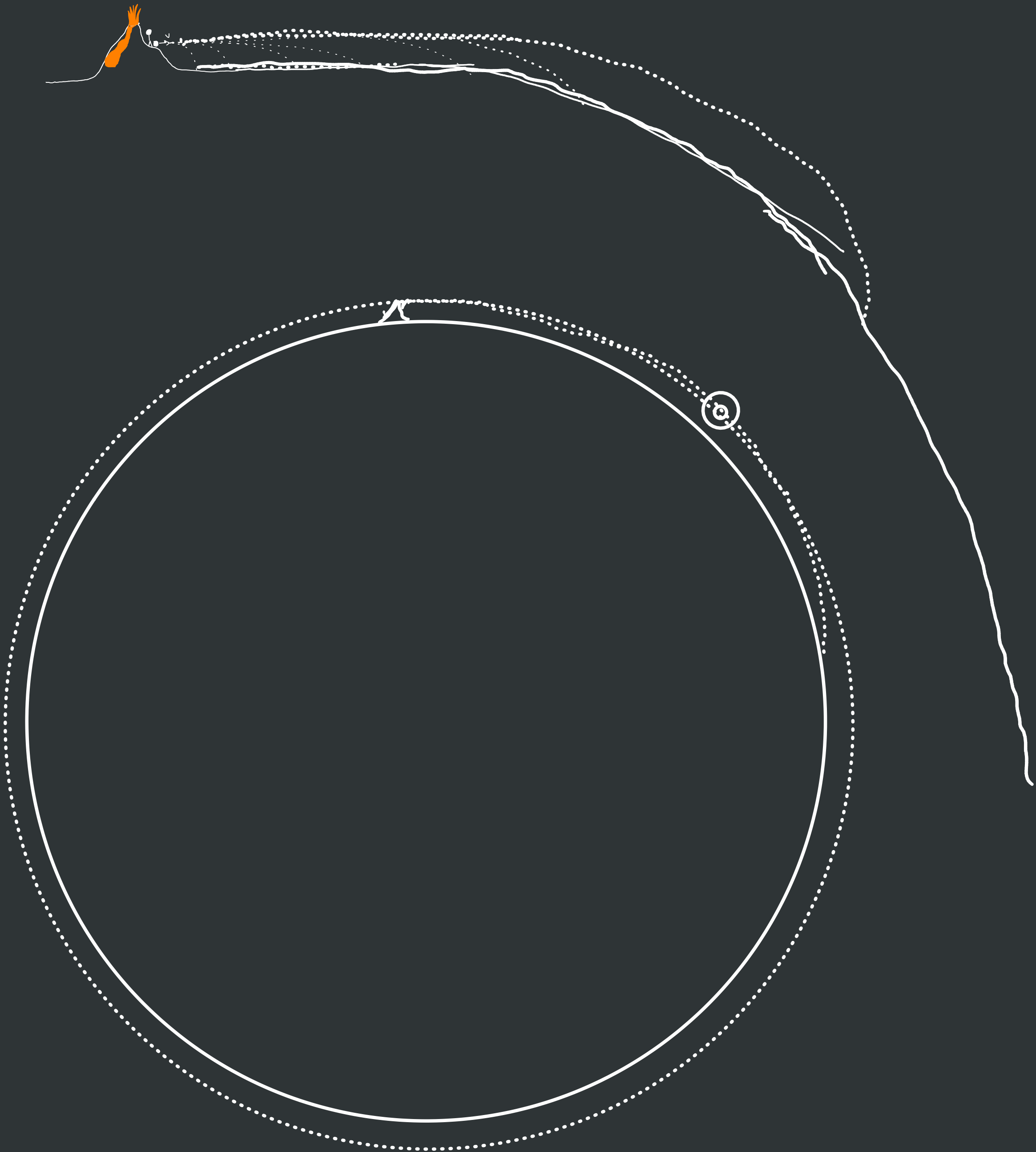
$+112\,N = +700\,N - n$

$n = 588\,N$

normal force at the bottom:

$F_{NET} = F_g + \text{normal}$

$-112\,N = +700\,N - \text{normal} \Rightarrow n = 812\,N$



$$m_{ball} = 1\,kg$$

$$F_g = 10\,N$$

$$r = r_e + h_{mountain}$$

$$r = 6.36 \cdot 10^6\,m + 9000\,m$$

$$F_g = F_{NET} = \frac{mv^2}{r}$$

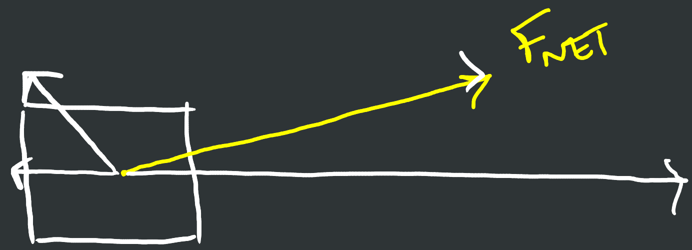
$$10N = \frac{1kg \cdot v^2}{(6.369 \cdot 10^6\,m)}$$

$$\frac{6.369 \cdot 10^{11}\,Nm}{1kg} = v^2$$

$$\boxed{V = 798{,}000\ m/s}$$

Three forces act on the object in the sketch. In what direction will the object move?

A. Upward
B. To the left
C. To the left and up
D. To the right
E. To the right and up



A 10.0 kg block on a smooth horizontal surface is acted upon by two forces: a horizontal force of 70 N acting to the left and a horizontal force of 30 N to the right. The acceleration of the block will be

A. 2.3 m/s^2 to the right.
B. 4.0 m/s^2 to the right.
C. 10.0 m/s^2 to the left.
D. 4.0 m/s^2 to the left.

$F_{NET} = +70N + (-30N) = 40N$

$F_{NET} = m \cdot a$

$40N = 10kg \cdot a \rightarrow a = 4 m/s^2$

An object weighs 30 newtons on Earth. What is its approximate mass?

A. 640 kg
B. 30 g
C. 12 kg
D. 3 kg
E. 294 k

$F_g = m \cdot g$

$30N = m \cdot 9.8 m/s^2$

$\frac{30N}{9.8 m/s} \approx 3\ kg = m$

A child, whose weight is 150 newtons, lifts a pumpkin from the ground with a force of 50 newtons. The force the pumpkin exerts on the child is

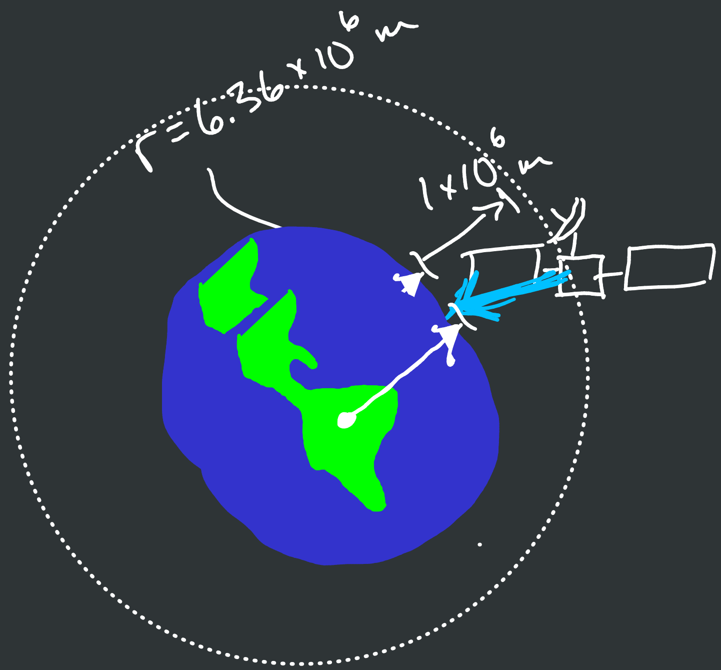
A. more than 50 newtons.
B. 50 newtons.
C. greater than zero but less than 50 newtons.
D. zero.

Your weight is 120 lb. Suppose you are standing on a scale in an elevator moving up with a constant speed of 4 m/s. What would be the reading on the scale?

A. 480 lb
B. 120 lb
C. 70 lb
D. 30 lb
E. 0

If a ball at the end of a string is whirled in a vertical circle at constant speed, the tension will be

A. the same throughout the motion.
B. greatest at the highest point in the motion.
C. greatest at the lowest point in the motion.
D. greatest at a point where the string is instantaneously parallel to the ground.



$M = 1 \times 10^6\ \text{kg}$

slightly wrong weight $= 1 \times 10^6\ \text{kg} \cdot 9.8\ \text{m/s}^2$

$= 1 \times 10^7\ \text{N}$

$F_{NET} = m a_c$

$$F_{NET} = \frac{m v^2}{r}$$

$$1 \times 10^7\ \text{N} = \frac{1 \cdot \cancel{10^6}\ \text{kg} \cdot v^2}{7.36 \times \cancel{10^6}\ \text{m}}$$

$$\sqrt{7.36 \cdot 10^7\ \frac{\text{m}^2}{\text{s}^2}} = \sqrt{v^2}$$

$v = 8{,}580\ \text{m/s}$

Newton's Law of Universal Gravitation

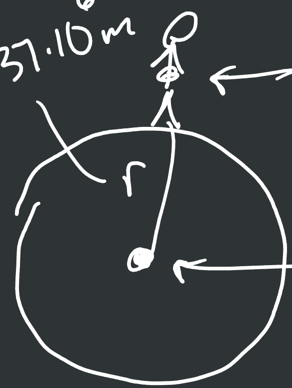
$$F_g = \frac{G \times mass_1 \times mass_2}{(distance)^2}$$

$$G = 6.67 \times 10^{-11} \frac{Nm^2}{kg^2}$$

$Mass_{earth} = 6 \cdot 10^{24}\ kg$

m_s

m_m



$9.8\ m/s^2$

$$F_g = \frac{G\, m_e \cdot m}{(r)^2}$$

$$= \frac{6.67 \cdot 10^{-11} \cdot 6 \cdot 10^{24} \cdot 70}{(6.36 \cdot 10^{6}\ m)^2} = \underline{\underline{692\ N}}$$

$$F_g = mg$$

$$= 70\ kg \cdot 9.8\ m/s^2 = \underline{\underline{686\ N}}$$

- Gravitational Force Field

cause ?

mass

effect ?

force exerted on another mass

$$F_g = \underline{\underline{g}} \cdot m$$

$$F_g = m \cdot \underline{\underline{g}}$$

9.8 ← gravitational field strength

on earth

$$g = \frac{G \cdot M_{object}}{(distance)^2}$$

- Centrifugal vs. Centripetal Force