Midterm 2 Solutions

Sunday, July 9, 2023 7:45 PM

For questions 1 and 2, **fill in the square** next to all correct answers. A given problem may have more than one correct answer. Each correctly bubbled answer will receive two points. There are **6** correct answers in this section and only the first **6** filled in answers will be graded. There is no partial credit.

1. Nessie, the wonder-dog (no super powers! Just wonderful), is in the process of jumping up from the floor. The only objects are the floor and Nessie (there is nothing else to cause an external force). Which of the following statements are true regarding this situation?

- ☐ (a) Before her feet leave the ground, as her center of mass is accelerating upwards, the force of gravity from the Earth on her is **larger** than the normal force from the floor.
- ☐ (b) Before her feet leave the ground, as her center of mass is accelerating upwards, the force of gravity from the Earth on her is **equal** to the normal force from the floor.

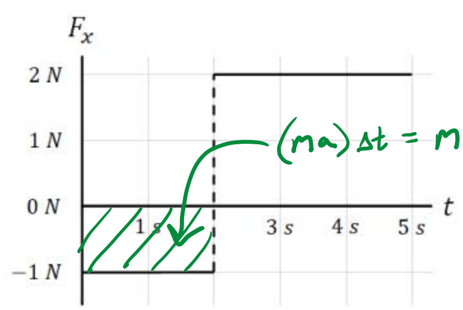
$\uparrow \vec{a}$ $\uparrow \sum \vec{F}$

- ☑ ✓ (c) Before her feet leave the ground, as her center of mass is accelerating upwards, the force of gravity from the Earth on her is **smaller** than the normal force from the floor.
- ☐ (d) After her feet leave the ground, as she is travelling upwards before she reaches the peak of her jump, the net force on Nessie is pointed **upwards**.
- ☐ (e) After her feet leave the ground, as she is travelling upwards before she reaches the peak of her jump, the net force on Nessie is **zero**.

$a \downarrow$ $\sum F \downarrow$

- ☑ ✓ (f) After her feet leave the ground, as she is travelling upwards before she reaches the peak of her jump, the net force on Nessie is pointed **downwards**.

2. A 2 kg object experiences a net force shown in the graph. The object starts from rest and moves only along the x-axis. Which of the following statements are true regarding the objects motion?

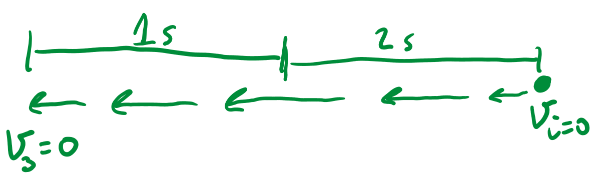


$(ma)\Delta t = m\Delta v$

$\underbrace{\sum F}_{\text{const}} = \underbrace{ma}_{\text{const}}$

- ☐ (a) The velocity of the object is constant between t = 0 s and t = 2 s.
- ☑ ✓ (b) The acceleration of the object is constant between t = 0 s and t = 2 s.
- ☑ ✓ (c) The speed of the object at t = 2 s is 1 m/s.
- ☐ (d) The speed of the object at t = 2 s is –2 m/s
- ☑ ✓ (e) The object's speed is zero at t = 3 s.
- ☐ (f) The object returns to it's starting location **at** t = 3 s.
- ☐ (g) The object returns to it's starting location **before** t = 3 s.
- ☑ ✓ (h) The object returns to it's starting location **after** t = 3 s.

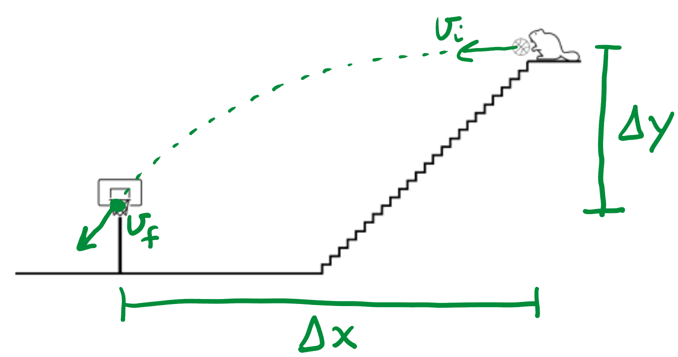
|—1s—|—2s—| $\Rightarrow \Delta v = 0$, but Δx is not zero



$\Rightarrow \Delta v_{0-3} = 0$, but Δx is not zero

3. (11 points) Bernice throws a ball from the top of the stands in Gill Coliseum. The ball travels through the air and lands in the basket. Bernice initially threw the ball horizontally with a speed of **20 m/s**. The height difference between the release point and the basket is **10.4 meters.**

(a) What is the horizontal distance between Bernice and the basket?



y

k	uk
Δy	Δt
v_{iy}	v_{fy}
a_y	

$$\Delta y = \cancel{v_{iy}}^{0} \Delta t + \frac{1}{2} a_y \Delta t^2$$

$$\Delta y = -\frac{1}{2} g \Delta t^2$$

$$\Delta t = \sqrt{\frac{-2\Delta y}{g}}$$

$$= 1.456 \text{ sec}$$

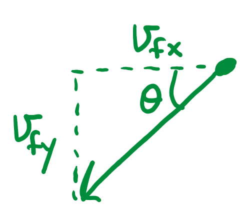
x

k	uk
Δt	Δx?
v_{ix}	
a_x	
v_{fx}	

$$\Delta x = v_{ix} \Delta t + \frac{1}{2} \cancel{a_x}^{0} \Delta t^2$$

$$\Delta x = v_{ix} \left(\sqrt{\frac{-2\Delta y}{g}} \right) = 29.1 \text{ m}$$

(b) At what angle is the ball travelling as it lands in the basket?



$$\Rightarrow \tan\theta = \frac{v_{fy}}{v_{fx}}$$

$$\Rightarrow \theta = 35.5^\circ \text{ from } -x \text{ to } -y$$

$$\text{or } 54.5^\circ \text{ from } -y \text{ to } -x$$

$$v_{fx} = v_{ix} + \cancel{a_x}^{0} \Delta t$$

$v_{fx} = v_{ix} + a_x \Delta t$

$v_{fx} = -20 \text{ m/s}$

$v_{fy} = \cancel{v_{iy}}^{0} + a_y \Delta t$

$= (-9.81 \text{ m/s}^2)(1.456 \text{ s}) = -14.28$

or 54.5° from −y to −x

4. (10 points) Benny is testing a new rocket design created by the architects at a university down the street. The rocket has a mass of **1300 kg**, starts from rest, and thankfully only travels along the x-axis. The rocket turns on and for the first **25 seconds** it experiences a net force of **1500 N** in the positive x-direction. The rocket then malfunctions, experiencing an unknown constant acceleration along the x-axis. Benny measures that **33 seconds** after the rocket malfunctioned, the rocket was located a total of only **120 meters** in the positive x-direction from it's starting location.

(a) How far did the rocket travel in the first 25 seconds?

Force analysis

$\Sigma F_x = m a_x$

$1500 \text{ N} = (1300 \text{ kg})\, a_x$

$a_x = 1.154 \text{ m/s}^2$

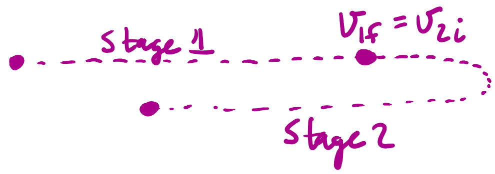
Kinematics

$\Delta x = \cancel{v_{ix}}^{0} \Delta t + \frac{1}{2} a_x \Delta t^2$

$\Delta x = \frac{1}{2}(1.154 \text{ m/s}^2)(25 \text{ s})^2$

$= 361.0 \text{ m}$

(b) What was the net force (include the direction!) on the rocket during the 33 seconds after it malfunctioned?



K	UK
Δt	a_2?
Δx_2	v_{i2}
	v_{f2}

$\Delta x_2 = v_{2i} \Delta t_2 + \frac{1}{2} a_2 \Delta t_2^2$

$\frac{2(120 - 361.0) - 2(28.84 \text{ m/s})(33 \text{ s})}{(33)^2} = a_2$

v_{f2}

$(33)^2$ $= a_2$

$a_2 = -2.19$

Connecting stage 1 & 2

$v_{1f} = v_{2i}$

$= v_{1i} + a_1 \Delta t$

$= 28.84 \, m/s$

$f_{net} = ma = \boxed{2{,}848 \, N \text{ in } -\hat{x}}$