You can draw here

Physics 111 - Class 4B
2D and 3D Motion II

Do not draw in/on this box!

September 29, 2021

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Class Outline

- Logistics / Announcements
- Clicker Questions
- Activity: Worked Problem

Logistics/Announcements

- Lab this week: Lab 2
- HW4 due this week on Thursday at 6 PM
- Learning Log 4 due on Saturday at 6 PM
- HW and LL deadlines have a 48 hour grace period
- Test/Bonus Test: Bonus Test 1 available this week
  - Test Window: Friday 6 PM - Sunday 6 PM

Figure 1.1 This image might be showing any number of things. It might be a whirlpool in a tank of water or perhaps a collage of paint and shiny beads done for art class. Without knowing the size of the object in units we all recognize, such as meters or inches, it is difficult to know what we're looking at. In fact, this image shows the Whirlpool Galaxy (and its companion galaxy), which is about 60,000 light-years in diameter (about $6 \times 10^{17} \text{km}$ across). (credit: modification of work by S. Beckwith (STScI) Hubble Heritage Team, (STScI/AURA), ESA, NASA)

Chapter Outline

Projectile Motion

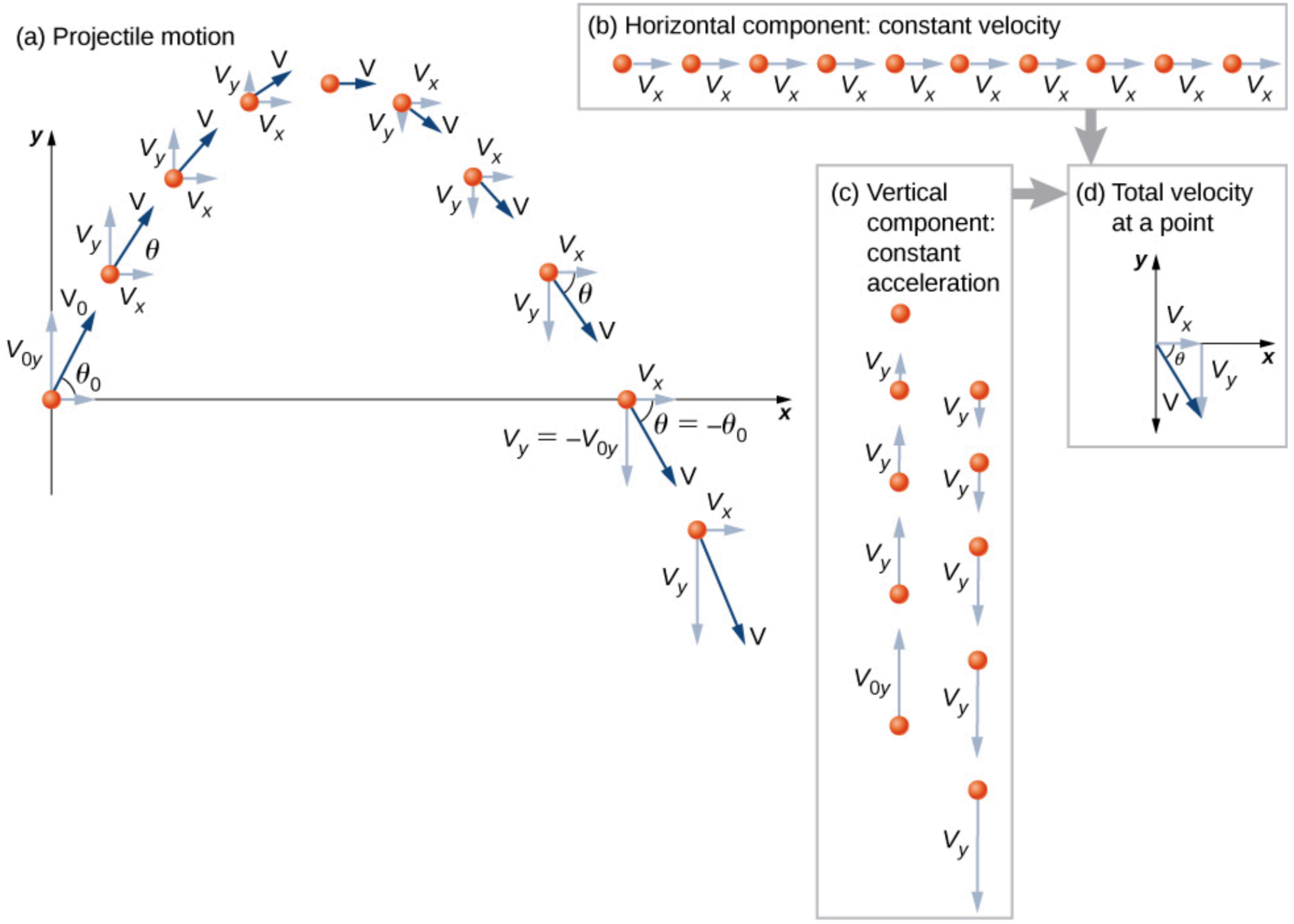


Figure 4.12 (a) We analyze two-dimensional projectile motion by breaking it into two independent one-dimensional motions along the vertical and horizontal axes. (b) The horizontal motion is simple, because $a_x = 0$ and v_x is a constant. (c) The velocity in the vertical direction begins to decrease as the object rises. At its highest point, the vertical velocity is zero. As the object falls toward Earth again, the vertical velocity increases again in magnitude but points in the opposite direction to the initial vertical velocity. (d) The *x* and *y* motions are recombined to give the total velocity at any given point on the trajectory.

Key Equations

Position vector	$\vec{\mathbf{r}}(t) = x(t)\hat{\mathbf{i}} + y(t)\hat{\mathbf{j}} + z(t)\hat{\mathbf{k}}$
Displacement vector	$\Delta\vec{\mathbf{r}} = \vec{\mathbf{r}}(t_2) - \vec{\mathbf{r}}(t_1)$
Velocity vector	$\vec{\mathbf{v}}(t) = \lim\limits_{\Delta t \to 0} \frac{\vec{\mathbf{r}}(t+\Delta t) - \vec{\mathbf{r}}(t)}{\Delta t} = \frac{d\vec{\mathbf{r}}}{dt}$
Velocity in terms of components	$\vec{\mathbf{v}}(t) = v_x(t)\hat{\mathbf{i}} + v_y(t)\hat{\mathbf{j}} + v_z(t)\hat{\mathbf{k}}$
Velocity components	$v_x(t) = \frac{dx(t)}{dt} \quad v_y(t) = \frac{dy(t)}{dt} \quad v_z(t) = \frac{dz(t)}{dt}$
Average velocity	$\vec{\mathbf{v}}_{\text{avg}} = \frac{\vec{\mathbf{r}}(t_2) - \vec{\mathbf{r}}(t_1)}{t_2 - t_1}$
Instantaneous acceleration	$\vec{\mathbf{a}}(t) = \lim\limits_{t \to 0} \frac{\vec{\mathbf{v}}(t+\Delta t) - \vec{\mathbf{v}}(t)}{\Delta t} = \frac{d\vec{\mathbf{v}}(t)}{dt}$
Instantaneous acceleration, component form	$\vec{\mathbf{a}}(t) = \frac{dv_x(t)}{dt}\hat{\mathbf{i}} + \frac{dv_y(t)}{dt}\hat{\mathbf{j}} + \frac{dv_z(t)}{dt}\hat{\mathbf{k}}$
Instantaneous acceleration as second derivatives of position	$\vec{\mathbf{a}}(t) = \frac{d^2x(t)}{dt^2}\hat{\mathbf{i}} + \frac{d^2y(t)}{dt^2}\hat{\mathbf{j}} + \frac{d^2z(t)}{dt^2}\hat{\mathbf{k}}$

Key Equations

Time of flight	$T_{\text{tof}} = \frac{2(v_0 \sin\theta_0)}{g}$
Trajectory	$y = (\tan\theta_0)x - \left[\frac{g}{2(v_0\cos\theta_0)^2}\right] x^2$
Range	$R = \frac{v_0^2 \sin 2\theta_0}{g}$
Centripetal acceleration	$a_C = \frac{v^2}{r}$
Position vector, uniform circular motion	$\vec{\mathbf{r}}(t) = A\cos\omega t\,\hat{\mathbf{i}} + A\sin\omega t\hat{\mathbf{j}}$
Velocity vector, uniform circular motion	$\vec{\mathbf{v}}(t) = \frac{d\vec{\mathbf{r}}(t)}{dt} = -A\omega\sin\omega t\hat{\mathbf{i}} + A\omega\cos\omega t\hat{\mathbf{j}}$
Acceleration vector, uniform circular motion	$\vec{\mathbf{a}}(t) = \frac{d\vec{\mathbf{v}}(t)}{dt} = -A\omega^2\cos\omega t\hat{\mathbf{i}} - A\omega^2\sin\omega t\hat{\mathbf{j}}$
Tangential acceleration	$a_T = \frac{d\lvert\vec{\mathbf{v}}\rvert}{dt}$
Total acceleration	$\vec{\mathbf{a}} = \vec{\mathbf{a}}_C + \vec{\mathbf{a}}_T$

Key Equations

Position vector in frame S is the position vector in frame S' plus the vector from the origin of S to the origin of S'	$\vec{\mathbf{r}}_{PS} = \vec{\mathbf{r}}_{PS'} + \vec{\mathbf{r}}_{S'S}$
Relative velocity equation connecting two reference frames	$\vec{\mathbf{v}}_{PS} = \vec{\mathbf{v}}_{PS'} + \vec{\mathbf{v}}_{S'S}$
Relative velocity equation connecting more than two reference frames	$\vec{\mathbf{v}}_{PC} = \vec{\mathbf{v}}_{PA} + \vec{\mathbf{v}}_{AB} + \vec{\mathbf{v}}_{BC}$
Relative acceleration equation	$\vec{\mathbf{a}}_{PS} = \vec{\mathbf{a}}_{PS'} + \vec{\mathbf{a}}_{S'S}$

Clicker Questions

CQ.4.4

A projectile is launched horizontally on level ground, with a launch speed v_0 that cannot be changed. How will the range (the horizontal distance traveled by the projectile before striking the ground) change if the launch angle θ is increased?

a) The distance will decrease as the angle increases until the angle reaches 45°, after which it will increase.

b) The distance will increase as the angle increases until the angle reaches 45°, after which it will decrease.

c) The distance will continually increase with the increase in the angle of projection of the projectile.

d) The distance will continually decrease with the increase in the angle of projection of the projectile.

A B C D E

CQ.4.5

You hit a ball horizontally from the top of a cliff that is $80\ \mathrm{m}$ tall. The ball has an initial velocity of $10.0\ \mathrm{m/s}$. What is the horizontal range of the ball?

a) $80\ \mathrm{m}$

b) $800\ \mathrm{m}$

c) $40\ \mathrm{m}$

d) $63\ \mathrm{m}$

e) $72\ \mathrm{m}$

A B C D E

CQ.4.7

Multi-part question

A football player punts the ball at a 45.0° angle. Without an effect from the wind, the ball would travel 60.0 m horizontally.

What is the initial speed of the ball?

a) Not enough information

b) 0.00 m/s

c) 28.8 m/s

d) 24.2 m/s

A B C D E

CQ.4.8

Multi-part question

A football player punts the ball at a 45.0° angle. Without an effect from the wind, the ball would travel 60.0 m horizontally.

When the ball is near its maximum height it experiences a brief gust of wind that reduces its horizontal velocity by 1.50 m/s. What distance does the ball travel horizontally?

a) 69.6 m

b) 57.4 m

c) 60.0 m

d) 57.8 m

A B C D E

Activity:
Worked Problem

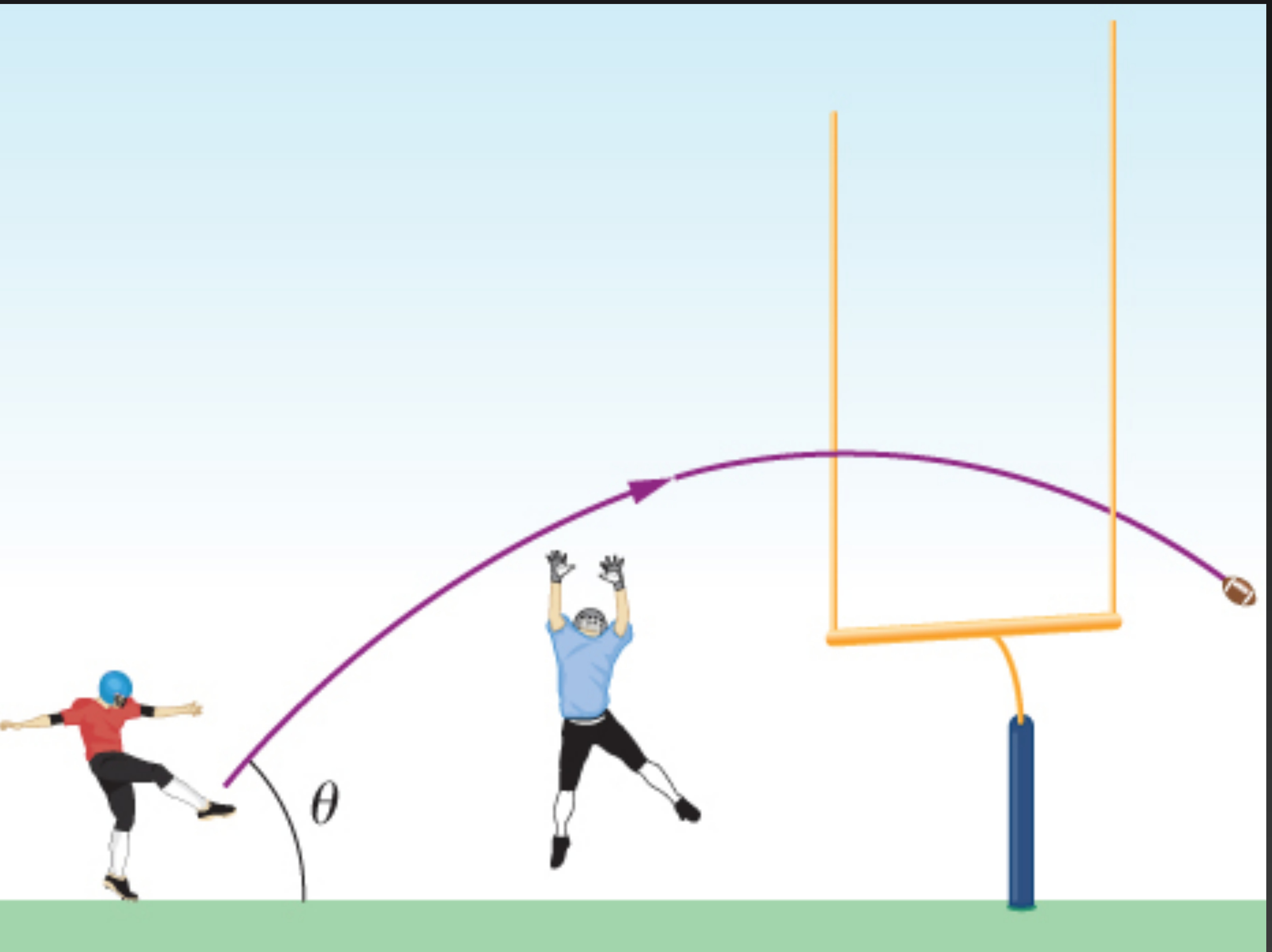
When a field goal kicker kicks a football as hard as he can at 45° to the horizontal, the ball just clears the 3-m-high crossbar of the goalposts 45.7 m away.

WP 4.2

(a) What is the maximum speed the kicker can impart to the football?

(b) In addition to clearing the crossbar, the football must be high enough in the air early during its flight to clear the reach of the onrushing defensive lineman. If the lineman is 4.6 m away and has a vertical reach of 2.5 m, can he block the 45.7-m field goal attempt?

(c) What if the lineman is 1.0 m away? Is the ball blocked?



WP 4.2

See you next class!

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