

1. A rock is thrown horizontally off the roof of a building at 18 m/s. What is the horizontal component of the velocity just before the rock hits the ground?
 - (A) -18 m/s
 - (B) -9.8 m/s
 - (C) 9.8 m/s
 - (D) 18 m/s

2. A juggler throws a ball at 0.22 m/s at an angle of 60.0° above the horizontal. What is the y-component of the velocity of the ball?
 - (A) 0.11 m/s
 - (B) 0.19 m/s
 - (C) 0.25 m/s
 - (D) 0.44 m/s

3. How much time does it take a soccer ball to travel 50.0 m horizontally if it is kicked with a velocity of 18.4 m/s at an angle of 30.0° above the horizontal?
 - (A) 0.184 s
 - (B) 0.319 s
 - (C) 3.14 s
 - (D) 5.43 s

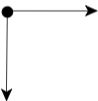


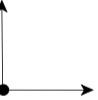
4. A ball is thrown horizontally with a speed of 10.0 m/s. If it hits the ground 4.0 s later, what is the magnitude of the y-component of its velocity just before it hits the ground?
 - (A) 0 m/s
 - (B) 39 m/s
 - (C) 49 m/s
 - (D) 98 m/s

5. Which expression represents the time it takes for a projectile, with initial velocity v_1 , at angle θ above the horizontal, to reach its maximum height?
 - (A) $v_1 g \cos \theta$
 - (B) $v_1 g \sin \theta$
 - (C) $\frac{v_1 \cos \theta}{g}$
 - (D) $\frac{v_1 \sin \theta}{g}$

7. Which movement is an example of projectile motion?
 - (A) climbing a wall
 - (B) running around a track
 - (C) throwing a ball off a cliff
 - (D) walking at a constant velocity

7. An egg is thrown in the air with a velocity of 15 m/s at 45° above the horizontal. What is its horizontal velocity and vertical acceleration when it reaches the maximum height?

	horizontal velocity (m/s)	vertical acceleration (m/s^2)
(A)	0	0
(B)	0	-9.8
(C)	11	0
(D)	11	-9.8

8. A projectile is launched at a 30.0° angle above the horizontal with a speed of 20.0 m/s. What is the vertical displacement after 3.0 s?
- (A) -74 m
 (B) -14 m
 (C) $+12$ m
 (D) $+31$ m
9. If a coin is pushed horizontally from a 1.2 m high table and lands 0.68 m from the base, what was the speed at which it left the table?
- (A) 1.4 m/s
 (B) 1.9 m/s
 (C) 2.8 m/s
 (D) 5.7 m/s
10. What is the vertical speed component of a projectile that is launched at an angle of 20.0° to the horizontal with an initial speed of 30.0 m/s?
- (A) $30.0 (\cos 20.0^\circ)$
 (B) $30.0 (\sin 20.0^\circ)$
 (C) $\frac{30.0}{\sin 20.0^\circ}$
 (D) $\frac{30.0}{\cos 20.0^\circ}$
11. Which best represents the velocity components of a projectile at its maximum height?
- (A) 
- (B) 
- (C) 
- (D) 
12. A projectile is shot horizontally at 40.0 m/s from a cannon located on a cliff 155 m high. How many seconds is the projectile in the air?
- (A) 0.258 s
 (B) 5.62 s
 (C) 11.0 s
 (D) 31.6 s
13. A ball thrown into the air has a horizontal velocity component of 12 m/s. What is the range of the ball if it lands after 3.0 s?
- (A) 4.0 m
 (B) 36 m
 (C) 51 m
 (D) 80 m
14. An arrow is fired at 45.5 m/s from a 5.75 m high tree branch, at an angle of 60° above the horizontal. What maximum height, above the ground, will the arrow reach?
- (A) 32.1 m
 (B) 73.4 m
 (C) 79.1 m
 (D) 84.9 m

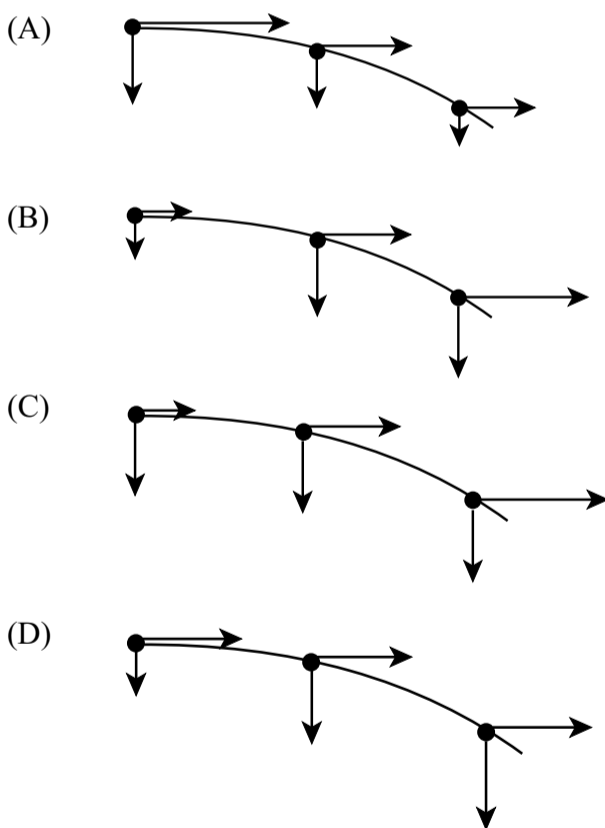
15. A ball is thrown at a 60° angle to the horizontal. As soon as the ball is released, the thrower runs along level ground, below the ball, and catches it 3.0 s later. If the thrower ran 12 m, what was the magnitude of the initial velocity?
- (A) 2.3 m/s
 (B) 4.0 m/s
 (C) 4.6 m/s
 (D) 8.0 m/s

16. If a ball is thrown at an initial speed of 8.0 m/s at an angle of 35° above the ground, what is the speed of the ball when it returns to its original height?
- (A) 4.6 m/s
 (B) 6.6 m/s
 (C) 8.0 m/s
 (D) 9.8 m/s

17. A rock is thrown horizontally from the top of a hill. If air friction is negligible, which best represents the horizontal and vertical accelerations?

	horizontal acceleration (m/s^2)	vertical acceleration (m/s^2)
(A)	0	-9.8
(B)	0	0
(C)	9.8	-9.8
(D)	9.8	0

18. Which diagram best represents the vertical and horizontal velocity components shortly after a ball is kicked from a cliff?



19. Which is constant for all projectiles?
- (A) horizontal displacement
 (B) horizontal velocity
 (C) vertical displacement
 (D) vertical velocity

20. If a coin is tossed horizontally from a 1.2 m high table and lands 0.68 m from the base, what was the speed at which it left the table?
- (A) 1.4 m/s
 (B) 1.9 m/s
 (C) 2.8 m/s
 (D) 5.7 m/s

21. What is the vertical speed component of a projectile that is launched at an angle of 20.0° to the horizontal with an initial speed of 30.0 m/s ?

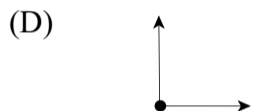
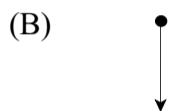
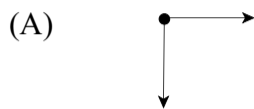
(A) $30.0 (\cos 20.0^\circ)$

(B) $30.0 (\sin 20.0^\circ)$

(C) $\frac{30.0}{\sin 20.0^\circ}$

(D) $\frac{30.0}{\cos 20.0^\circ}$

22. Which best represents the velocity components of a projectile at its maximum height?



23. A projectile is shot horizontally at 40.0 m/s from a cannon located on a cliff 155 m high. How many seconds is the projectile in the air?

(A) 0.258 s

(B) 5.62 s

(C) 11.0 s

(D) 31.6 s

24. A ball thrown into the air has a horizontal velocity component of 12 m/s . What is the range of the ball if it lands after 3.0 s ?

(A) 4.0 m

(B) 36 m

(C) 51 m

(D) 80 m

25. An arrow is fired at 45.5 m/s from a 5.75 m high tree branch, at an angle of 60° above the horizontal. What maximum height, above the ground, will the arrow reach?

(A) 32.1 m

(B) 73.4 m

(C) 79.1 m

(D) 84.9 m

26. A ball is thrown at a 60° angle to the horizontal. As soon as the ball is released, the thrower runs along level ground, below the ball, and catches it 3.0 s later. If the thrower ran 12 m , what was the magnitude of the initial velocity?

(A) 2.3 m/s

(B) 4.0 m/s

(C) 4.6 m/s

(D) 8.0 m/s

27. Which is constant for any given projectile?

(A) horizontal displacement

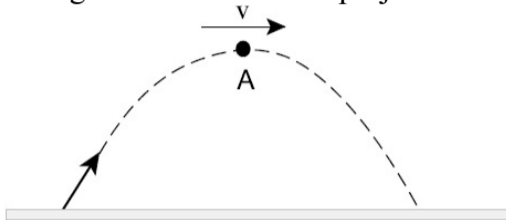
(B) horizontal velocity

(C) vertical displacement

(D) vertical velocity

28. Which demonstrates projectile motion?
 (A) ball rolling up a hill
 (B) car driving down a street
 (C) horse galloping around an oval track
 (D) rock rolling off the edge of a cliff
29. If a projectile is launched at an angle of 65° from the horizontal at a speed of 2.1 m/s, what is the maximum height reached by the object?
 (A) 0.040 m
 (B) 0.097 m
 (C) 0.18 m
 (D) 0.23 m

30. The diagram below shows a projectile moving with speed, v , at the top of its path.



Which vector best represents the acceleration of the projectile at position A?

(A)



(B)



(C)



(D)



31. If a steel ball was launched horizontally from a height of 90.0 cm and lands 1.3 m from the base, what was the initial velocity?
 (A) 0.30 m/s
 (B) 2.7 m/s
 (C) 3.0 m/s
 (D) 7.1 m/s
31. Which illustrates projectile motion?
 (A) driving a car around a banked curve
 (B) dropping a rock from a building
 (C) juggling
 (D) running
32. A ball kicked from the ground at 12.0 m/s and 28° from the horizontal, returns to the ground in 5.0 s. What is the ball's speed just before it hits the ground?
 (A) 0 m/s
 (B) 5.6 m/s
 (C) 11 m/s
 (D) 12 m/s
33. If a ball is thrown at an angle of 35° from the ground, at a speed of 8.0 m/s, what is the magnitude of the vertical component of the initial velocity?
 (A) 4.6 m/s
 (B) 5.6 m/s
 (C) 6.6 m/s
 (D) 8.0 m/s

34. A ball is thrown horizontally at 10.0 m/s. If it hits the ground 2.00 s later, what is the magnitude of the x-component of its velocity just before it hits the ground?
- (A) 0 m/s
 (B) 10.0 m/s
 (C) 20.0 m/s
 (D) 30.0 m/s
35. If a coin is pushed horizontally from a 1.2 m high table and lands 0.75 m from the base, what was the speed at which it left the table?
- (A) 0.38 m/s
 (B) 1.5 m/s
 (C) 1.9 m/s
 (D) 3.0 m/s
36. Which represents the range for a projectile launched horizontally with velocity, v , from height, h ?

(A)

$$v \sin \theta \sqrt{\frac{h}{4.9}}$$

(B)

$$-v \cos \theta \sqrt{\frac{h}{4.9}}$$

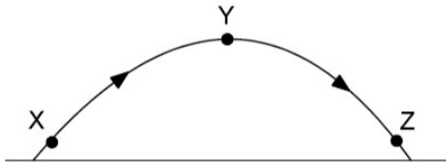
(C)

$$v \sqrt{\frac{h}{4.9}}$$

(D)

$$v \left(\frac{h}{4.9} \right)$$

37. What is the acceleration of the projectile at each point in the diagram below?



	Acceleration (m/s^2)		
	X	Y	Z
(A)	-9.8	-9.8	-9.8
(B)	-9.8	0	9.8
(C)	9.8	9.8	-9.8
(D)	9.8	0	-9.8

38. If a projectile is launched from ground level with an initial velocity of 65 m/s at 30.0° above the horizontal, what is its total time in the air?
- (A) 3.3 s
 (B) 6.6 s
 (C) 12 s
 (D) 13 s
39. An object is projected horizontally from a 0.95 m high table at a velocity of 12 m/s. How far from the base of the table will the object hit the floor?
- (A) 2.3 m
 (B) 5.3 m
 (C) 11 m
 (D) 27 m

40. Two arrows are launched at the same time with the same initial velocity. Arrow X is fired at an angle of 60° to the horizontal, and arrow Y is fired at an angle of 45° to the horizontal. Which best describes the motion of arrow X compared to the motion of arrow Y?
- (A) Arrow X has a longer flight time and longer horizontal range.
 (B) Arrow X has a longer flight time and shorter horizontal range.
 (C) Arrow X has a shorter flight time and longer horizontal range.
 (D) Arrow X has a shorter flight time and shorter horizontal range.
41. What is the direction of acceleration for any projectile?
- (A) up
 (B) down
 (C) left
 (D) right
42. What is the range of a projectile launched horizontally at 15 m/s with a flight time of 4.5 s?
- (A) 3.3 m
 (B) 59 m
 (C) 68 m
 (D) 99 m
43. A rock is launched with a horizontal velocity of 3.0 m/s and a vertical velocity of 4.0 m/s. What is the magnitude of the velocity of the rock at its maximum height?
- (A) 0 m/s
 (B) 3.0 m/s
 (C) 4.0 m/s
 (D) 5.0 m/s
44. A projectile is launched from ground level with an initial velocity of 65 m/s at an angle of 60.0° above the horizontal. How much time does it take to return to ground level?
- (A) 2.4 s
 (B) 3.4 s
 (C) 5.6 s
 (D) 11 s
45. What is the maximum height of a projectile launched at 120 m/s at an angle of 30.0° above the horizontal.
- (A) 3.1 m
 (B) 5.3 m
 (C) 180 m
 (D) 550 m
46. A golfer hits a golf ball with a velocity of 75 m/s at an angle of 15° to the horizontal. What are the horizontal and vertical components of the initial velocity?

	horizontal velocity (m/s)	vertical acceleration (m/s^2)
(A)	0	75
(B)	19	72
(C)	72	19
(D)	75	0

47. A stone is thrown horizontally from the edge of a cliff and lands in the water below. If the stone is in the air for 2.8 s, how high is the cliff?
- (A) 14 m
 (B) 27 m
 (C) 38 m
 (D) 77 m

48. A swimmer runs horizontally off the end of a wharf at 1.2 m/s and lands in the water 2.4 s later. How far does she have to swim to get back to the wharf?
- (A) 0.50 m
 (B) 2.0 m
 (C) 2.9 m
 (D) 5.8 m

49. A football is kicked and follows a parabolic path. Which represents the velocity of the football at its maximum height?



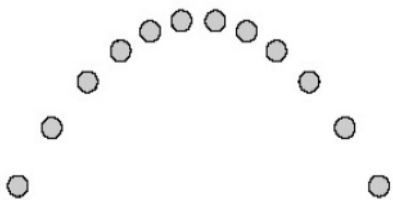
50. A plane flying horizontally with a speed of 50.0 m/s at a height of 161 m, drops a package when it is directly over a tent. How far from the tent will the package land?
- (A) 161 m
 (B) 169 m
 (C) 287 m
 (D) 1640 m

51. A stone is thrown upward from the top of a building at an angle of 30.0° to the horizontal with an initial speed of 20.0 m/s. If the stone lands on the ground 4.22 s later, how tall is the building?
- (A) 14.2 m
 (B) 21.5 m
 (C) 45.1 m
 (D) 129 m

52. A person runs horizontally off the end of a cliff and lands in the water 1.3 s later. How high is the cliff?
- (A) 1.6 m
 (B) 6.4 m
 (C) 8.3 m
 (D) 13 m

53. A marble is launched horizontally from a table at 12 m/s and lands on the floor 0.25 s later. What is the range of the marble?
- (A) 0.021 m
 (B) 0.31 m
 (C) 3.0 m
 (D) 48 m

54. Which describes a ball thrown in the air that traces the path shown?



- (A) The acceleration of the ball at the top of its motion is zero.
- (B) The acceleration of the ball keeps changing.
- (C) The velocity of the ball at the top of its motion is zero.
- (D) The velocity of the ball keeps changing.

55. A projectile is launched with an initial velocity of 14 m/s at an angle of 25° above the horizontal. What is the speed of the projectile at its maximum height?

- (A) 0 m/s
- (B) 5.9 m/s
- (C) 13 m/s
- (D) 14 m/s

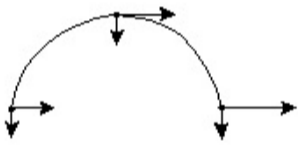



56. A golf ball is hit from ground level with an initial velocity of 63 m/s at an angle of 31° above the horizontal. How long will it take the ball to hit the ground?

- (A) 3.3 s
- (B) 5.5 s
- (C) 6.6 s
- (D) 11 s

57. A marble is launched horizontally from the top of a building. How far has the marble fallen when the vertical component of its velocity is 16 m/s [down]?

- (A) 0.82 m
- (B) 1.6 m
- (C) 13 m
- (D) 26 m

58. Which represents the velocity components of a projectile?

<p>(A)</p> 	<p>(B)</p> 
<p>(C)</p> 	<p>(D)</p> 

59. An arrow is shot horizontally with a velocity of 12 m/s. If the range is 24 m, how long is the arrow in the air?

- (A) 0.50 s
- (B) 2.0 s
- (C) 12 s
- (D) 24 s

60. What are the horizontal and vertical components of a projectile launched with a velocity of 16.0 m/s at an angle of 40.0° above the horizontal?

	v_x (m/s)	v_y (m/s)
(A)	10.3	12.3
(B)	12.3	10.3
(C)	12.3	16.0
(D)	16.0	12.3

61. A soccer ball is kicked with a speed of 15.0 m/s at 30.0° above the ground. What is its height at 0.60 s?

- (A) 1.6 m
- (B) 2.7 m
- (C) 6.0 m
- (D) 6.3 m

62. A catapult fires a large stone as shown. What is the maximum height reached by the stone?

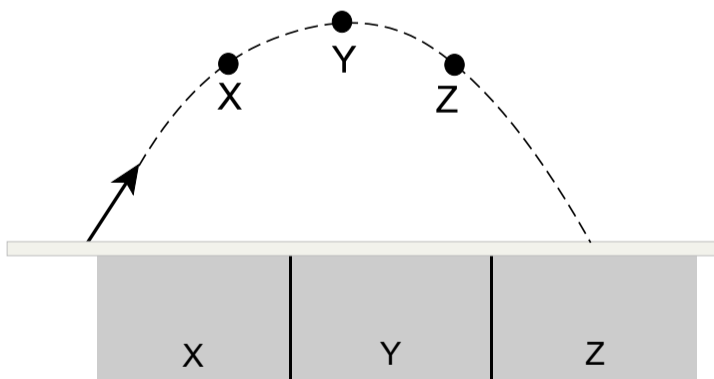


- (A) 1.62 m
- (B) 11.2 m
- (C) 51.3 m
- (D) 103 m

63. A golf ball is launched with an initial velocity, v_0 , at an angle θ above the ground. Which expression describes the time required for the golf ball to land on the ground?

- (A) $\frac{-2v_0}{a}$
- (B) $\frac{-2v_0 \cos \theta}{a}$
- (C) $\frac{-2v_0 \sin \theta}{a}$
- (D) $\frac{-v_0 \sin \theta}{a}$

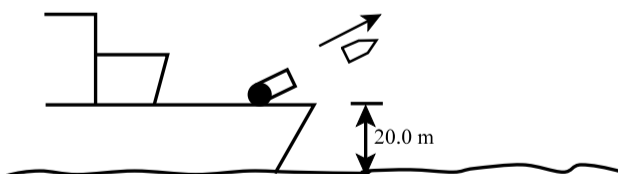
64. Which represents the vertical component of the velocity at points X, Y and Z for the object following the parabolic path shown below?



65. What is the range of a ball thrown horizontally at 12 m/s if its time of flight is 3.0 s?
 (A) 0.25 m
 (B) 4.0 m
 (C) 12 m
 (D) 36 m
66. An arrow is fired from a bow with an initial velocity of 18.0 m/s at an angle of 35.0° above the horizontal. How far, horizontally, has the arrow travelled in 1.45 s?
 (A) 12.4 m
 (B) 15.0 m
 (C) 21.4 m
 (D) 26.1 m
67. A ball is launched with an initial velocity of 28.0 m/s at 40.0° above the horizontal. How long does it take for the ball to reach its maximum height?
 (A) 1.68 s
 (B) 1.84 s
 (C) 2.19 s
 (D) 2.86 s
68. A golf ball is launched at an angle of 15.0° from the ground. What was the initial speed of the ball if it lands on the ground 3.42 s later?
 (A) 16.8 m/s
 (B) 17.3 m/s
 (C) 64.7 m/s
 (D) 129 m/s
69. A cannonball is fired on Earth at an angle of 45° above the ground and has a range of 125 m. If the same cannonball is fired on Jupiter where $g = 24.6 \text{ m/s}^2$, which combination of changes would have to occur so that the cannonball still has a range of 125 m?

	Launch Angle	Launch Speed
(A)	decrease	same
(B)	increase	same
(C)	same	decrease
(D)	same	increase

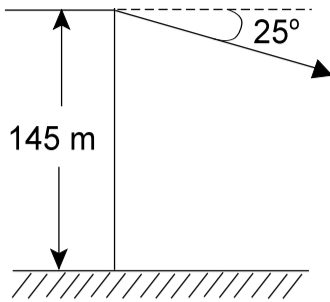
1. If a rock is thrown horizontally from a 45.0 m high cliff with a velocity of 20.0 m/s, how far from the base of the cliff does the rock hit the ground? **JUNE 2004**
2. In the diagram below, a shell is shot from a cannon, with an initial speed of $4.4 \times 10^2 \text{ m/s}$, at 30.0° from the deck of a ship. If the ship is at rest and the shell is launched 20.0 m above sea level, how far will the shell travel horizontally from its original position into the sea? Assume friction is negligible. **JUNE 2004**



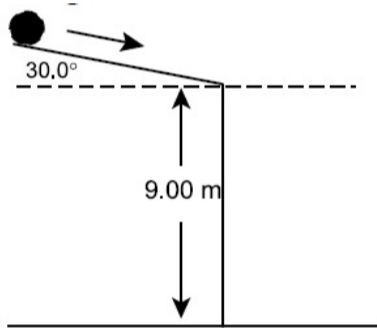
3. (a) As a plane flies horizontally at 65.0 m/s, it releases a package from a height of $1.20 \times 10^3 \text{ m}$. **JUNE 2005**
4. (i) What is the horizontal distance the package travels after it is released?
 (ii) What is the final velocity of the package? **AUGUST 2005**

5. The diagram below represents a cannon located on a 145 m high cliff. If the cannon fires a cannonball at a 25° angle below the horizontal, with an initial velocity of 75.0 m/s, how far will the cannonball travel in the horizontal direction before it hits the ground?

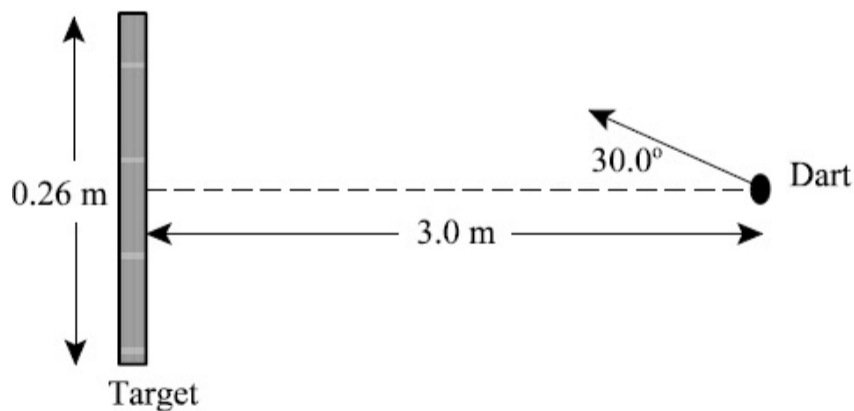
AUGUST 2005



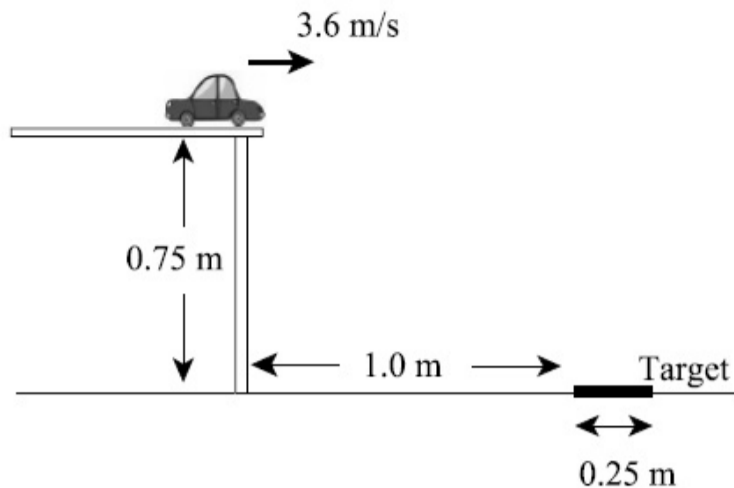
6. A parcel is dropped from a plane flying overhead with a constant horizontal speed of 75 m/s. If the range is 1.2×10^3 m, from what height was the parcel dropped? Assume air resistance is negligible. Show workings. **JUNE 2006**
7. A strike in baseball occurs between 0.50 m and 1.0 m directly above home plate. A pitcher, 18.0 m from home plate, throws a ball with an initial velocity of 17.0 m/s at 15° above the horizontal. If the ball is released 2.0 m above the ground, will the pitch be a strike? Show workings. **JUNE 2006**
8. A ball rolls off an incline at 20.0 m/s, as shown in the diagram below. At what horizontal distance from the wall will the ball hit the ground? **AUGUST 2006**



9. A juggler throws a ball upward at an angle of 65° to the horizontal, with an initial speed of 3.2 m/s. How far apart should the juggler hold her hands in order to catch the ball at the same level from which it was thrown? **JUNE 2007**
10. In the diagram below a dart that is in line with the midpoint of a 0.26 m high target, is thrown toward the target with a speed of 6.0 m/s at a 30.0° angle. Determine whether the dart will hit the target if it is 3.0 m away.



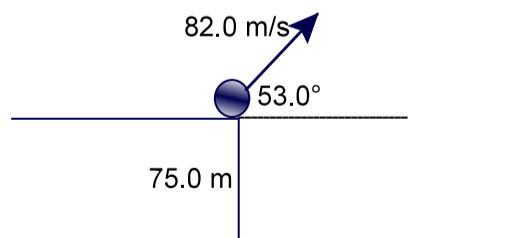
11. In a laboratory activity, students launch a toy car horizontally off a table with a speed of 3.6 m/s as shown. If a 0.25 m wide target is placed 1.0 m from the base of the table, determine whether the car will hit the target. **AUGUST 2007**



12. Explain why beginning jugglers prefer large dwell ratios, while professional jugglers prefer smaller dwell ratios. **AUGUST 2007**
13. Ball A is rolled down a 30.0° ramp on a 1.0 m high table, and exits the table horizontally at 2.0 m/s. A second identical ball B, is rolled down the same ramp but exits the table with a speed of 2.0 m/s at a 30.0° angle. Calculate which ball will travel the greatest horizontal distance from the base of the table. **JUNE 2008**



14. A fish sees a bug on a tree branch that is 4.1 m above the water, and tries to knock it down by shooting a jet of water with an initial velocity of 11.7 m/s at an angle of 35° to the surface of the water. With the aid of a diagram, calculate whether it is possible for the angler fish to hit the bug. **JUNE 2008**
15. A golfer hits a golf ball from ground level with a speed of 25 m/s at 35° above the horizontal. Calculate the magnitude of the velocity of the ball when it has travelled a horizontal distance of 42 m. **AUGUST 2008**
16. A ball is thrown from a 75.0 m high cliff, with an initial velocity of 82.0 m/s, at an angle of 53.0° above the horizontal. Calculate the range of the ball when it hits the ground below. **JUNE 2009**



17. A ball is thrown with an initial velocity of 82.0 m/s at an angle of 53.0° below the horizontal as shown. Calculate the range of the ball if it is thrown from a height of 10.0 m. **AUGUST 2009**