# Projectile Motion:

The motion of any object launched from a location horizontally or at an angle to the horizontal. This is also two motions going on at the same time.

## Objectives:

- To find a vector resultant using the algebraic method including the magnitude and direction.
- To find a vector resultant using the algebraic method including the magnitude and direction.
- To solve problems involving projectile motion including objects with horizontal velocity and objects launched at an angle.

## Projectile Motion Formulas:

$$A_y = A\sin\theta$$

$$A_y = A\cos\theta$$

$$v_f = v_i + at$$

$$d = v_i t + \frac{1}{2}at^2$$

$${v_f}^2 = {v_i}^2 + 2ad$$

$$a = \frac{\Delta v}{t}$$

$$\sin\theta = \frac{opposite}{hypotenuse}$$

$$\cos\theta = \frac{adjacent}{hypotenuse}$$

$$\tan\theta = \frac{opposite}{adjacent}$$

## Concepts to Watch Out For:

- There is NO acceleration in the horizontal (constant velocity)
- Vertical acceleration is always -9.81 m/s$^2$ (acceleration due to gravity)
- Time is usually found in the vertical
- Time is the same for both components
- $v_y$ = 0 m/s at the apex of flight (it is still accelerating downward at 9.81m/s$^2$)
- There are always two sets of givens and unknowns
- Do NOT use the use the original vector after it's been broken up.
- $v_{iy}$ = 0 for objects thrown horizontally off a cliff

**The University of the State of New York**

**REGENTS HIGH SCHOOL EXAMINATION**

# PHYSICAL SETTING
# PHYSICS

# Projectile Motion NOTES:

**Notice. . .**

**A scientific or graphing calculator, a centimeter ruler, a protractor, and a copy of the *2002 Edition Reference Tables for Physical Setting/Physics*, which you may need to answer some questions in this examination, must be available for your use while taking this examination.**

**The use of any communications device is strictly prohibited when taking this examination. If you use any communications device, no matter how briefly, your examination will be invalidated and no score will be calculated for you.**

**DO NOT OPEN THIS EXAMINATION BOOKLET UNTIL THE SIGNAL IS GIVEN.**

PS/PHYSICS

## Part A

**Answer all questions in this part.**

*Directions* (1–8): For *each* statement or question, write on the separate answer sheet the *number* of the word or expression that, of those given, best completes the statement or answers the question.

1 A golf ball is hit at an angle of 45° above the horizontal. What is the acceleration of the golf ball at the highest point in its trajectory? [Neglect friction.]

(1) 9.8 m/s$^2$ upward
(2) 9.8 m/s$^2$ downward
(3) 6.9 m/s$^2$ horizontal
(4) 0.0 m/s$^2$

2 A ball is thrown horizontally at a speed of 24 meters per second from the top of a cliff. If the ball hits the ground 4.0 seconds later, approximately how high is the cliff?

(1) 6.0 m
(2) 39 m
(3) 78 m
(4) 96 m

3 A golf ball is propelled with an initial velocity of 60. meters per second at 37° above the horizontal. The horizontal component of the golf ball's initial velocity is

(1) 30. m/s
(2) 36 m/s
(3) 40. m/s
(4) 48 m/s

4 A projectile is launched at an angle above the ground. The horizontal component of the projectile's velocity, $v_x$, is initially 40. meters per second. The vertical component of the projectile's velocity, $v_y$, is initially 30. meters per second. What are the components of the projectile's velocity after 2.0 seconds of flight? [Neglect friction.]

(1) $v_x$ = 40. m/s and $v_y$ = 10. m/s
(2) $v_x$ = 40. m/s and $v_y$ = 30. m/s
(3) $v_x$ = 20. m/s and $v_y$ = 10. m/s
(4) $v_x$ = 20. m/s and $v_y$ = 30. m/s

5 A soccer ball kicked on a level field has an initial vertical velocity component of 15.0 meters per second. Assuming the ball lands at the same height from which it was kicked, what is the total time the ball is in the air? [Neglect friction.]

(1) 0.654 s
(2) 1.53 s
(3) 3.06 s
(4) 6.12 s

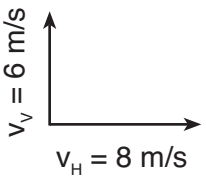
6 A baseball is thrown at an angle of 40.0° above the horizontal. The horizontal component of the baseball's initial velocity is 12.0 meters per second. What is the magnitude of the ball's initial velocity?

(1) 7.71 m/s
(2) 9.20 m/s
(3) 15.7 m/s
(4) 18.7 m/s

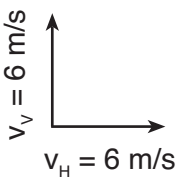
7 A golf ball is given an initial speed of 20. meters per second and returns to level ground. Which launch angle above level ground results in the ball traveling the greatest horizontal distance? [Neglect friction.]

(1) 60.°
(2) 45°
(3) 30.°
(4) 15°

8 Which combination of initial horizontal velocity, ($v_H$) and initial vertical velocity, ($v_v$) results in the greatest horizontal range for a projectile over level ground? [Neglect friction.]



( 1 )



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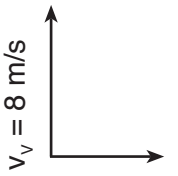

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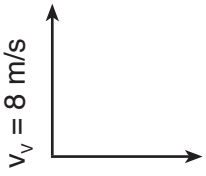


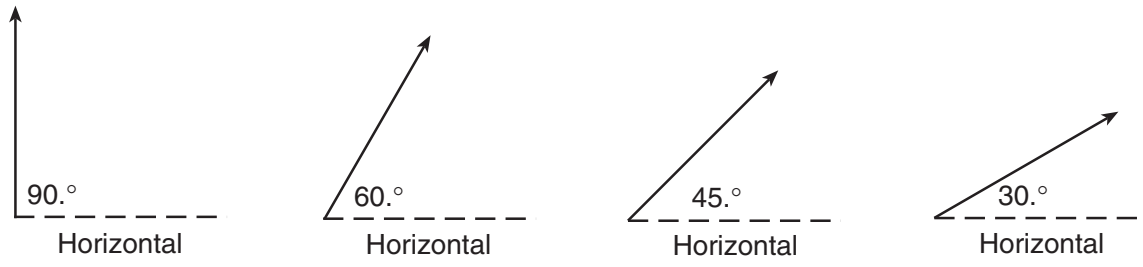
( 4 )

**Part B-1**

**Answer all questions in this part.**

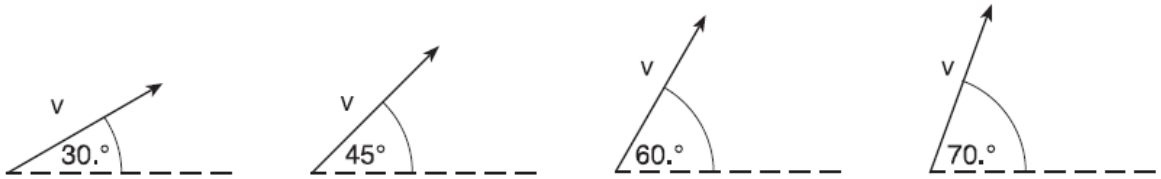
*Directions* (9–11): For *each* statement or question, write on the separate answer sheet the *number* of the word or expression that, of those given, best completes the statement or answers the question.

9 A volleyball hit into the air has an initial speed of 10. meters per second. Which vector best represents the angle above the horizontal that the ball should be hit to remain in the air for the greatest amount of time?



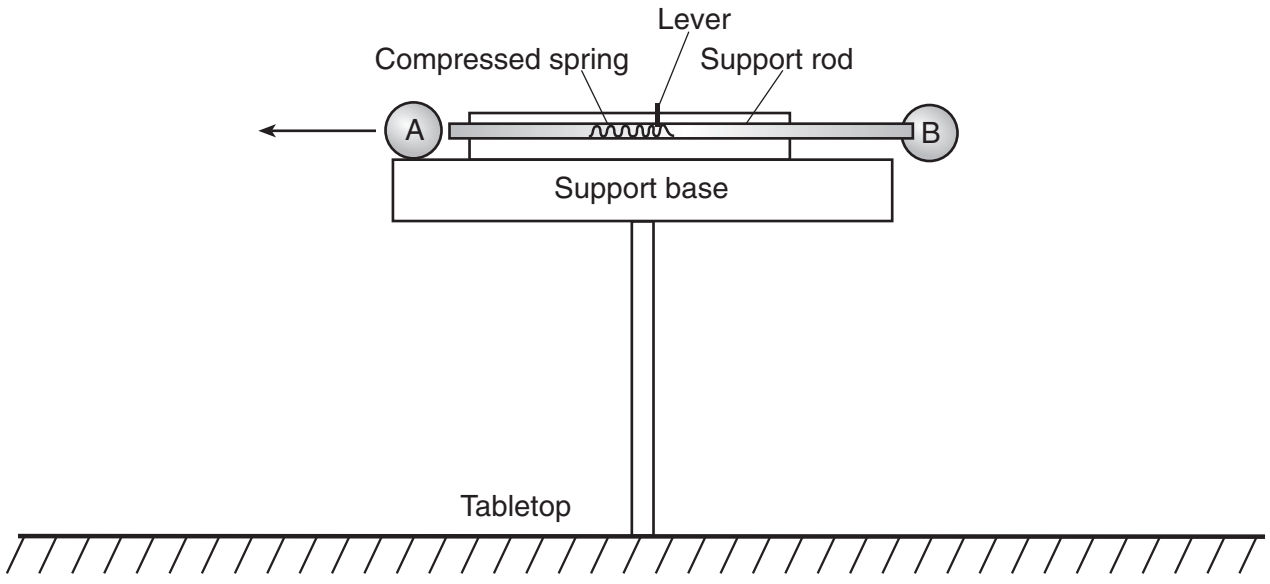

( 1 ) ( 2 ) ( 3 ) ( 4 )

10 Four identical projectiles are launched with the same initial speed, $v$, but at various angles above the level ground. Which diagram represents the initial velocity of the projectile that will have the largest total horizontal displacement? [Neglect air resistance.]




( 1 ) ( 2 ) ( 3 ) ( 4 )

11 The diagram below represents a setup for demonstrating motion.




When the lever is released, the support rod withdraws from ball *B*, allowing it to fall. At the same instant, the rod contacts ball *A*, propelling it horizontally to the left. Which statement describes the motion that is observed after the lever is released and the balls fall? [Neglect friction.]

(1) Ball *A* travels at constant velocity.
(2) Ball *A* hits the tabletop at the same time as ball *B*.
(3) Ball *B* hits the tabletop before ball *A*.
(4) Ball *B* travels with an increasing acceleration.

## Part B–2

**Answer all questions in this part.**

*Directions* (12–14): Record your answers in the spaces provided in your answer booklet. Some questions may require the use of the *2006 Edition Reference Tables for Physical Setting/Physics.*

Base your answers to questions 12 through 14 on the information below and on your knowledge of physics.

A football is thrown at an angle of 30.° above the horizontal. The magnitude of the horizontal component of the ball's initial velocity is 13.0 meters per second. The magnitude of the vertical component of the ball's initial velocity is 7.5 meters per second. [Neglect friction.]

12 On the axes *in your answer booklet*, draw a graph representing the relationship between the horizontal displacement of the football and the time the football is in the air. [1]

13–14 The football is caught at the same height from which it is thrown. Calculate the total time the football was in the air. [Show all work, including the equation and substitution with units.] [2]

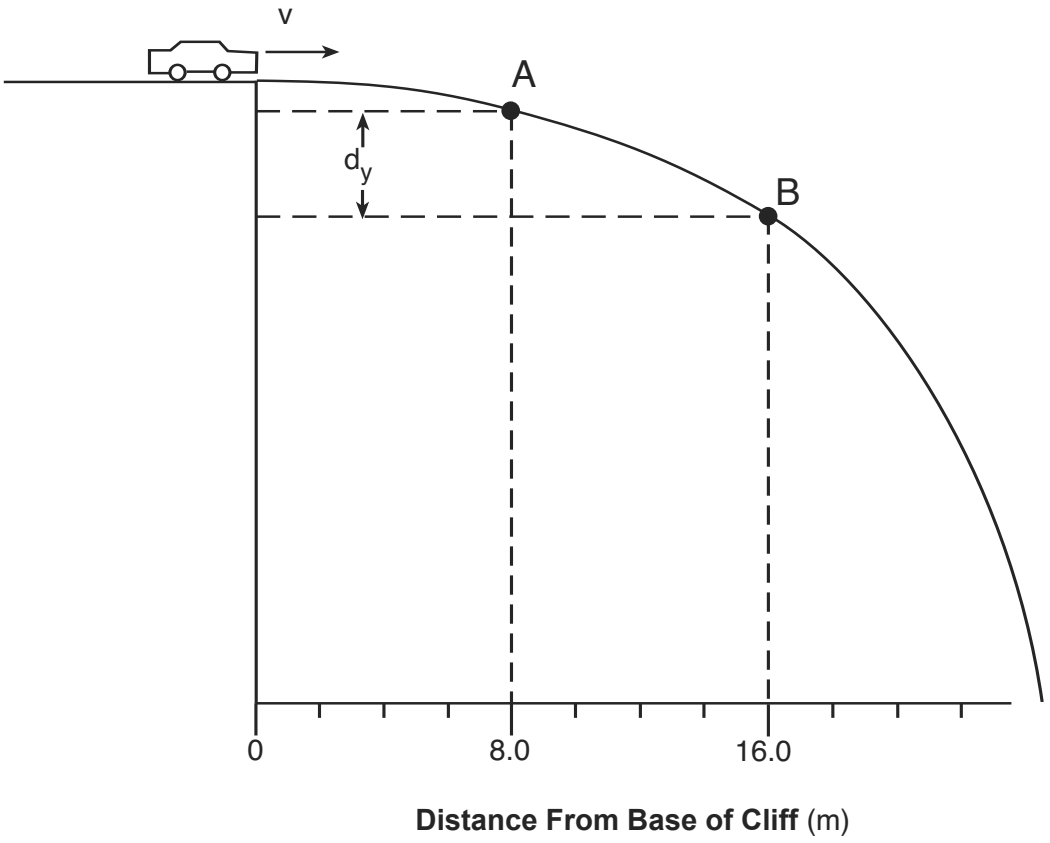
## Part C

**Answer all questions in this part.**

*Directions* (15–22): Record your answers in the spaces provided in your answer booklet.

Base your answers to questions 15 through 17 on the information below.

The path of a stunt car driven horizontally off a cliff is represented in the diagram below. After leaving the cliff, the car falls freely to point *A* in 0.50 second and to point *B* in 1.00 second.



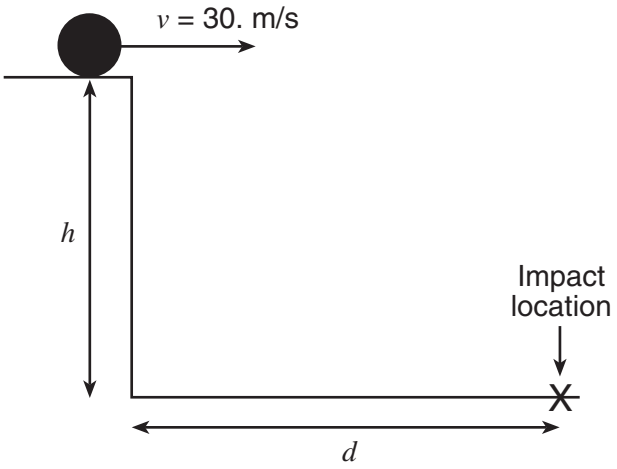

15 Determine the magnitude of the horizontal component of the velocity of the car at point *B*. [Neglect friction.] [1]

16 Determine the magnitude of the vertical velocity of the car at point *A*. [1]

17 Calculate the magnitude of the vertical displacement, $d_y$, of the car from point *A* to point *B*. [Neglect friction.] [Show all work, including the equation and substitution with units.] [2]

Base your answers to questions 18 through 20 on the information and diagram below.

A projectile is launched horizontally at a speed of 30. meters per second from a platform located a vertical distance $h$ above the ground. The projectile strikes the ground after time $t$ at horizontal distance $d$ from the base of the platform. [Neglect friction.]




18 On the diagram *in your answer booklet*, sketch the theoretical path of the projectile. [1]

19 Calculate the horizontal distance, $d$, if the projectile's total time of flight is 2.5 seconds. [Show all work, including the equation and substitution with units.] [2]

20 Express the projectile's total time of flight, $t$, in terms of the vertical distance, $h$, and the acceleration due to gravity, $g$. [Write an appropriate equation and solve it for $t$.] [2]

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21-22 A toy rocket is launched twice into the air from level ground and returns to level ground. The rocket is first launched with initial speed $v$ at an angle of 45° above the horizontal. It is launched the second time with the same initial speed, but with the launch angle increased to 60.° above the horizontal. Describe how *both* the total horizontal distance the rocket travels and the time in the air are affected by the increase in launch angle. [Neglect friction.] [2]

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# PHYSICAL SETTING
# PHYSICS

**ANSWER SHEET**

Student . . . . . Sex: ☐ Male ☐ Female Grade . . . . . .

Teacher . . . . . School . . . . . .

**Record your answers to Part A and Part B–1 on this answer sheet.**

**Part A**

1 . . . . . .

2 . . . . . .

3 . . . . . .

4 . . . . . .

5 . . . . . .

6 . . . . . .

7 . . . . . .

8 . . . . . .

**Part A Score**

**Part B–1**

9 . . . . . .

10 . . . . . .

11 . . . . . .

**Part B–1 Score**

**Write your answers to Part B–2 and Part C in your answer booklet.**

**The declaration below should be signed when you have completed the examination.**

**I do hereby affirm, at the close of this examination, that I had no unlawful knowledge of the questions or answers prior to the examination and that I have neither given nor received assistance in answering any of the questions during the examination.**

**Signature**

Tear Here

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REGENTS HIGH SCHOOL EXAMINATION

# PHYSICAL SETTING
# PHYSICS

**ANSWER BOOKLET**

Student . . . . . Sex: ☐ Male ☐ Female

Teacher . . . . . .

School . . . . . Grade . . . . .

**Answer all questions in Part B–2 and Part C. Record your answers in this booklet.**

| Part | Maximum Score | Student's Score |
|---|---|---|
| A | 8 | |
| B–1 | 3 | |
| B–2 | 3 | |
| C | 8 | |

**Total Written Test Score (Maximum Raw Score: 85)**

**Final Score (From Conversion Chart)**

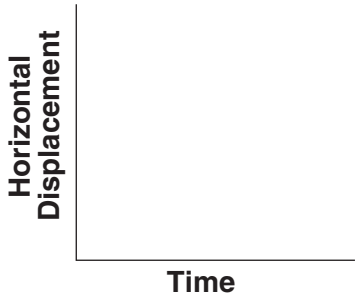
**Raters' Initials:**

**Rater 1** . . . . . **Rater 2** . . . . .

## Part B–2

**For Raters Only**

**12**




**12** ☐

**13–14**

**13** ☐

**14** ☐

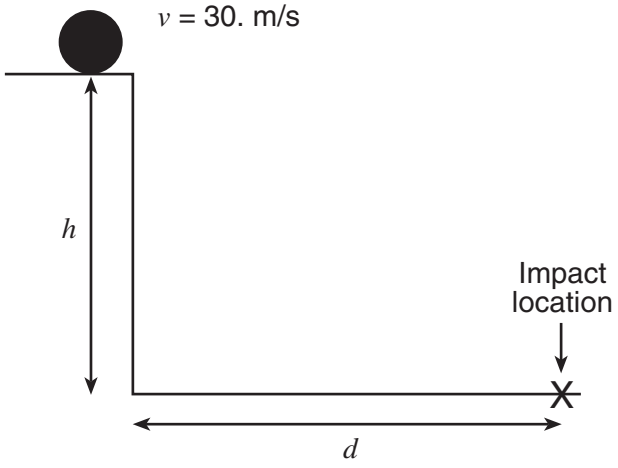
**Part C**

**15** _____ **m/s**

**16** _____ **m/s**

**17**

**18**




**19**

**20**

**For Raters Only**

**15** ☐

**16** ☐

**17** ☐

**18** ☐

**19** ☐

**20** ☐

21-22 _____

_____

21 ☐

22 ☐