PHYS 105 · Chapter 4: Motion in Two and Three Dimensions

Past-Exam Review — questions from PSU past midterm (Major 1 & 2) and final exams

Constant: g = 9.81 m/s^2 · The source of each question is shown in [brackets].

Part 1: Multiple-Choice Questions (33)

Indicate the answer choice that best completes the statement or answers the question.

4.1 – 4.3 Position, Velocity and Acceleration in Two Dimensions

Q1. *Motion in two dimensions with constant velocity along a straight line means:* **[Midterm 202]**

A *Both acceleration components equal zero*
B *Both displacement components equal zero*
C *Both of the above*
D *None of the above*

Q2. *A boat moves from position $r_i = (5\hat{x} - 3\hat{y})$ m to position $r_f = (-\hat{x} + 2\hat{y})$ m in 2 seconds. What is its average velocity?* **[Midterm 241]**

A $(-3\hat{x} + 2.5\hat{y})\,m/s$
B $(6\hat{x} - 5\hat{y})\,m/s$
C $(3\hat{x} - 6\hat{y})\,m/s$
D $(-6\hat{x} - 5\hat{y})\,m/s$

Q3. *A dragonfly is observed at $r_i = (-4.50\text{ m})\hat{x} + (3.00\text{ m})\hat{y}$. Two seconds later it is at $r_f = (2.00\text{ m})\hat{x} + (8.50\text{ m})\hat{y}$. What is its average velocity?* **[Midterm 242]**

A $(3.25\hat{x} + 2.75\hat{y})\,m/s$
B $(-3.25\hat{x} + 5.75\hat{y})\,m/s$
C $(3.25\hat{x} - 5.75\hat{y})\,m/s$
D $(-1.25\hat{x} + 2.75\hat{y})\,m/s$

Q4. *An insect travels from $r_i = (6\hat{x} - 2\hat{y})$ m to $r_f = (12\hat{x} + 2\hat{y})$ m in 4 seconds. What is its average velocity?* **[Midterm 233]**

A $1.5\hat{x} + \hat{y}$
B $4.5\hat{x} - \hat{y}$
C $1.5\hat{x}$
D $-1.5\hat{x} - \hat{y}$

Q5. *An object travels from the point (−5 m, 14 m) to the point (25 m, −4 m) in 10 seconds. What is the magnitude of its average velocity?* **[Midterm 211]**

A *1.7 m/s*
B *3.5 m/s*
C *10.7 m/s*
D *8.3 m/s*

Q6. *A particle moves in the xy-plane with constant acceleration $(5\hat{x} - 3\hat{y})$ m/s^2. If its velocity at some moment is $(19\hat{x} - 10\hat{y})$ m/s, what is its velocity 3 seconds later?* **[Midterm 211]**

A $62\hat{x} - 32\hat{y}\,m/s$
B $32\hat{x} - 62\hat{y}\,m/s$
C $34\hat{x} - 19\hat{y}\,m/s$
D $19\hat{x} - 34\hat{y}\,m/s$

Q7. *A bird moving with velocity $3\hat{x}$ m/s changes its velocity to $(5\hat{x} - 2\hat{y})$ m/s in 2 seconds. What is the magnitude of its average acceleration?* **[Midterm 201]**

A $2\ m/s^2$
B $0\ m/s^2$
C $1.4\ m/s^2$
D $2.8\ m/s^2$

Q8. *A car moving at 20 m/s toward the east changes its velocity to 28 m/s toward the south in 4 seconds. What is the magnitude of its average acceleration?* **[Final 182]**

A $8.6\ m/s^2$
B $3\ m/s^2$
C $12\ m/s^2$
D $8\ m/s^2$

Q9. *A car's initial velocity is $(12\ m/s)\hat{x}$ and its final velocity 1.0 s later is $(-12\ m/s)\hat{y}$. What is the magnitude of the car's average acceleration?* **[Final 202]**

A $15\ m/s^2$
B $17\ m/s^2$
C $12\ m/s^2$
D $24\ m/s^2$

4.4 Projectile Motion

Q10. *What is the shape of the path followed by a projectile?* **[Major 2 · 202]**

A Parabola
B Straight line
C Circle
D None of the above

Q11. *What is the acceleration vector of an object while it is in projectile motion?* **[Midterm 251]**

A $-g\hat{y}$
B $g\hat{y}$
C $-\frac{1}{2}gt^2\hat{y}$
D It depends on the initial velocity

Q12. *A golfer launches a ball at 40° above the horizontal. Ignoring air resistance, which statement about the ball's acceleration while it is in the air is correct?* **[Midterm 252]**

A It is zero during the whole flight.
B It is zero only at the highest point.
C It decreases from $9.81\ m/s^2$ to zero.
D It is $9.81\ m/s^2$ downward the whole time.

Q13. *What is the horizontal acceleration of a projectile?* **[Final 231 · Major 2 · 202]**

A Zero
B g (the acceleration due to gravity)
C The initial velocity of the projectile
D The final velocity of the projectile

Q14. *The acceleration of a projectile in the horizontal (x) direction is equal to:* **[Final 241]**

A *its acceleration in the vertical direction*
B *its initial speed*
C *9.81 m/s^2*
D *zero*

Q15. *At the maximum height of a projectile's trajectory:* **[Midterm 232]**

A *The vertical velocity is zero.*
B *The horizontal velocity is zero.*
C *Both velocities are zero.*
D *The projectile stops moving.*

Q16. *A ball is thrown at 45° above the horizontal. At the top of its path, which statement about its velocity is true?* **[Midterm 243]**

A *It is directed vertically downward*
B *Its horizontal component is zero*
C *Its vertical component is zero*
D *Both of its components are zero*

Q17. *For a projectile launched at an angle with initial velocity v_0, what are v_x and v_y at the maximum height?* **[Midterm 242]**

A $v_x = v_{0x}, v_y = -v_{0y}$
B $v_x = 0, v_y = -v_{0y}$
C $v_x = v_{0x}, v_y = 0$
D $v_x = -v_{0x}, v_y = -v_{0y}$

Q18. *A projectile is launched with v_0 = 40 m/s at 30° above the horizontal. Its velocity at the maximum height is:* **[Final 241]**

A $(34.6\,m/s)\,x$
B $(40\,m/s)\,x$
C $(34.6\,m/s)\,x - (20\,m/s)\,\hat{y}$
D $(-34.6\,m/s)\,\hat{y}$

Q19. *For which launch angle θ is the range of a projectile (landing at the launch height) maximum?* **[Major 2 · 202]**

A *30° above the horizontal*
B *45° above the horizontal*
C *55° above the horizontal*
D *60° above the horizontal*

Q20. *Two cannonballs are launched horizontally at the same time off a cliff. They have different masses and different horizontal speeds. Which strikes the ground first?* **[Major 2 · 202]**

A *The heaviest one*
B *The lightest one*
C *The slowest one*
D *They strike the ground at the same time*

Q21. *A player kicks a football at 53° above the horizontal with a speed of 20 m/s. How long is the ball in the air before it reaches the ground?* **[Midterm 232]**

A *1.63 s*
B *3.26 s*
C *20 s*
D *39 s*

Q22. *A tennis ball is thrown from ground level at 30° above the horizontal. If it takes 2 s to reach the top of its trajectory, what is the magnitude of its initial velocity?* **[Final 202]**

A *4.9 m/s*
B *19.6 m/s*
C *39.2 m/s*
D *9.8 m/s*

Q23. *How much time does it take a soccer ball to travel 20.0 m horizontally if it is kicked at 18.4 m/s at 30.0° above the horizontal?* **[Midterm 242]**

A *0.18 s*
B *1.08 s*
C *1.26 s*
D *2.17 s*

Q24. *A ball is thrown at 30.0° above the horizontal. If it covers a horizontal distance of 1.40 m in 1.25 s, what is its initial speed?* **[Final 242]**

A *1.29 m/s*
B *1.12 m/s*
C *1.42 m/s*
D *1.56 m/s*

Q25. *A ball is launched horizontally from the edge of a table. It lands on the floor 1.30 m from the base of the table after 1.25 s. What is its initial speed?* **[Midterm 251]**

A *1.04 m/s*
B *1.63 m/s*
C *2.55 m/s*
D *0.55 m/s*

Q26. *A bowling ball rolls off a 1.25 m tall horizontal table and hits the ground 1.75 m from the base of the table. What was its launch speed?* **[Final 202]**

A *2.72 m/s*
B *8.13 m/s*
C *3.46 m/s*
D *1.64 m/s*

Q27. *You throw a stone horizontally from a height of 1.5 m with an initial speed of 10 m/s. Neglecting air resistance, what horizontal distance does it cover before reaching the ground?* **[Final 182]**

A *15 m*
B *4.03 m*
C *5.53 m*
D *7.03 m*

Q28. *A stone is thrown horizontally at 10 m/s from the edge of a cliff. Its time of flight to the bottom is 4.3 s. What is the height of the cliff?* **[Final 222]**

A *22 m*
B *181 m*
C *43 m*
D *91 m*

Q29. *A helicopter flies horizontally at 35.0 m/s at an altitude of 155 m. A wheel detaches and falls. With what speed does the wheel strike the ground?* **[Midterm 252]**

A *65.3 m/s*
B *56.5 m/s*
C *45.5 m/s*
D *70.1 m/s*

Q30. *A helicopter travels at 30 m/s at a constant altitude of 140 m. If a wheel falls off, with what speed does it hit the ground?* **[Midterm 232]**

A *40 m/s*
B *60 m/s*
C *50 m/s*
D *56 m/s*

Q31. *A ball is kicked from the ground at 20 m/s at an angle of 60° above the horizontal. What is the maximum height it reaches?* **[Final 182]**

A *20.4 m*
B *5.1 m*
C *4.1 m*
D *15.3 m*

Q32. *An object is launched from the ground at 40 m/s at 50° above the horizontal. What is the maximum height it reaches?* **[Final 211]**

A *12.5 m*
B *1.56 m*
C *47.9 m*
D *938.8 m*

Q33. *A catapult launches a stone at 45.0 m/s at 55.0° above the horizontal. What maximum height does it reach?* **[Final 231]**

A *45.7 m*
B *32.7 m*
C *69.3 m*
D *83.2 m*

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Part 2: Problems (12)

Solve the following problems and show your work in detail.

Problem 1. *On level ground, a projectile is launched at 40.0 m/s at 60.0° above the horizontal.* [Midterm 251]

a) *Find the components of the initial velocity.*

b) *Find the time to reach the highest point.*

c) *How far from the launch point does it land?*

d) *Find v_x and v_y at $t = 2.0$ s.*

Problem 2. *A stone is thrown toward a cliff of height h at 51.0 m/s at 60.0° above the horizontal. It hits point A at the top of the cliff 5.50 s after launch.* [Midterm 252]

a) *Find v_{0x} and v_{0y}.*

b) *Find the height h of the cliff.*

c) *Find the speed of the stone just before it strikes A.*

d) *Find the maximum height H above the ground.*

Problem 3. *A ball is kicked from the ground at 45 m/s directed 40° above the horizontal.* **[Midterm 241]**

a) *Write v_0 in unit-vector notation.*

b) *Find the maximum height.*

c) *Find the x and y positions after 4 s.*

d) *Find the speed and direction after 4 s.*

Problem 4. *A ball is launched horizontally from the edge of a 20-m-high platform at 35 m/s.* **[Midterm 242]**

a) *Find its position (x, y) at t = 1.5 s (origin at the ground below the edge).*

b) *Find v_x and v_y at t = 1.5 s.*

c) *Find the speed and direction at t = 1.5 s.*

Problem 5. *A rock is thrown horizontally from a high cliff at v_0 = 5 m/s and reaches the ground below in 5 s.* **[Midterm 233]**

a) *What is the height of the cliff?*

b) *What horizontal distance does it cover?*

c) *Find its speed and direction just before it lands.*

Problem 6. *A ball is thrown horizontally at 40 m/s from a height of 10 m.* **[Midterm 243]**

a) *Find v_x and v_y after 1.2 s.*

b) *Find the speed and direction after 1.2 s.*

c) *Find the height of the ball after 1.2 s.*

d) *How long does it take to reach the ground, and how far does it go?*

Problem 7. *A stone is thrown horizontally from a 10 m high building and lands 25 m from its base.* **[Midterm 201]**

a) *How long does it take to reach the ground?*

b) *At what speed v_0 was it thrown?*

c) *What is its velocity vector as it hits the ground?*

Problem 8. *A ball is kicked at 30° above the horizontal at 20 m/s from the edge of a 100-m-high building.* **[Midterm 211]**

a) *How long does it take to reach the ground?*

b) *How far from the base of the building does it land?*

c) *What is its velocity vector as it hits the ground?*

Problem 9. *A player throws a ball horizontally at 20 m/s toward point A. The second baseman catches it at point B, 1.0 s later.* **[Major 2 · 202]**

a) *How far apart are the two players?*

b) *Find the vertical distance AB.*

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Problem 10. *A placekicker kicks a football at 50° above the horizontal with an initial speed of 22 m/s.* **[Major 2 · 202]**

a) *Find the maximum height H.*

b) *Find the time of flight.*

c) *Find the range.*

Problem 11. *A ball is thrown at 45° above the horizontal with an initial speed of 20 m/s and lands at the same level.* **[Final 221]**

a) *What is the range of the ball?*

b) *What is the total time of flight?*

c) *Find the velocity components at the maximum height.*

Problem 12. *A defense cannon at sea level fires a ball at 82 m/s at 63° above the horizontal toward a pirate ship.* **[Final 222]**

a) *How long is the ball in the air?*

b) *What is the maximum height?*

c) *Find the horizontal distance R to the ship.*