Name: _____ **Date:** _____

Variable Acceleration & Vector Calculus Physics Challenge for University

Examine projectile motion in resistive media and non-linear paths across 10 rigorous analytical problems requiring calculus-based synthesis.

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1. A particle moves along a trajectory defined by $r(t) = (a\cos\omega t)i + (b\sin\omega t)j$. At any time t, the acceleration vector a(t) is:

A. Parallel to the velocity vector v(t) at all points.
B. Directed toward the origin and proportional to the displacement r(t).
C. Constant in both magnitude and direction.
D. Perpendicular to the displacement vector r(t).

2. An object experiences a jerk (the time derivative of acceleration) that is constant and non-zero. The position of this object as a function of time is best described by a polynomial of degree ___.

A. Two
B. Three
C. Four
D. One

3. In a curvilinear path, it is possible for an object to have a constant speed and a non-zero acceleration simultaneously.

A. True
B. False

4. Consider a rocket whose acceleration increases linearly with time: $a(t) = kt$. If the rocket starts from rest at the origin, what is its displacement x after time T?

A. $(1/2)kT^2$
B. $(1/3)kT^3$
C. $(1/6)kT^3$
D. kT

5. A projectile is launched at an angle θ with initial velocity v. In the presence of linear air resistance ($F = -bv$), the time taken to reach maximum height is _____ than in a vacuum.

A. Longer
B. Infinite
C. The same
D. Shorter

6. A particle moves such that its velocity is given by $v = kx$, where k is a constant. The acceleration of the particle is:

A. Zero

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B. $k^2 / 2$
C. Dependent on x
D. k / (2x)

7. The area under an acceleration-time graph from t1 to t2 represents the total displacement of the object during that interval.

A. True
B. False

8. A ball is thrown vertically upward in a medium where resistance is proportional to the square of the speed (v^2). Which statement regarding the terminal velocity (Vt) is correct?

A. It is reached when the drag force equals the weight of the ball.
B. The ball reaches it immediately upon release.
C. It only applies to the upward phase of the motion.
D. Acceleration is max at Vt.

9. If a particle's position vector is r(t) = t^2 i + e^t j, the tangential component of acceleration at t=0 is _____.

A. 0
B. 1
C. 2
D. e

10. In 2D kinematics, if the x-component of acceleration is zero, the horizontal velocity of the particle must remain constant regardless of the y-component of acceleration.

A. True
B. False