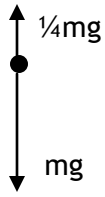
AP Physics C
Air Resistance and Calculus

Name _____

1. (Algebra Problem) Mr. Bruce, whose mass is 70 kg, decides to go skydiving. He jumps out of a plane at an altitude of 2000 m at time t=0 seconds and encounters air resistance that is equal to a quarter of his weight.



a. What is his acceleration and what is the net force acting on him?

$\Sigma F = 514.5$ N

$a = 7.35$ m/s^2

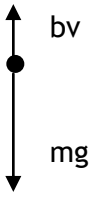
b. Assume instead that he fell for a time t=8 seconds before the air resistance started acting on him. Calculate the time it takes for him to hit the ground. Beware the quadratic formula on this one! Hint: You will need to break this problem up into two time periods: t = 0-8 s, and from t = 8s until hitting the ground.

$t = 21.3$ s

c. Assume that he falls for 8 seconds freely under gravity and then for another 8 seconds under the air resistance mentioned in the first problem. After these 16 seconds, he opens his parachute and falls at a constant velocity equal to his velocity at t=16 seconds. Calculate how long it takes him to reach the ground. Hint: Break this one up into three time periods.

t = 22 s

2. (Calculus Problem) On another day, Mr. Bruce again goes skydiving, but this time, he encounters an air resistance that is proportional to his velocity. The air resistance is of the form $F_{air} = bv$, where b is a constant, positive number.



a. Write a Newton's 2nd Law expression relating Mr. Bruce's velocity and his acceleration in terms of m, g, b, v, and t. (remember, a = dv/dt)

b. What is his terminal velocity in terms of m, g, and b? (hint: acceleration = zero at terminal velocity)

c. What are the units of b?

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d. Using the differential equation you wrote in (a), solve the differential equation to find Mr. Bruce's velocity as a function of time during the fall. Assume Mr. Bruce's initial velocity is zero. Hint: Isolate dv/dt and v first.

$$v = \frac{mg}{b}\left(1 - e^{-\frac{b}{m}t}\right)$$

e. At what time will Mr. Bruce's velocity be v=50m/s if b=12?

t = 12.1 s

f. Sketch rough graphs of Mr. Bruce's position, velocity, and acceleration vs time.