Calculus I
Section 3.1 – Rates of Change; Physics Applications

1. A stone is dropped from a 32 foot building. Its height (in feet) is given by $h(t) = -16t^2 + 32$ where t is in seconds.

    a. How long will it take for the stone to reach the ground?

    b. What is the average velocity of the stone for the entire trip?

    c. What is the impact speed of the stone?

2. A slingshot launches a stone vertically so that the height of the stone is given by the function $h(t) = -16t^2 + 300t + 6$, where h is in feet and t is in seconds.

    a. Find the average velocity of the stone from 0 to 4 seconds.

    b. Find the velocity of the stone at 4 seconds.

    c. Find the initial velocity of the stone.

    d. How long will it take for the stone to reach its maximum height (HINT: What will the velocity be when the stone reaches its maximum height?)

    e. How high will the stone go?

    f. How long after the stone was launched will it take to return to the ground?

    g. What is the impact velocity of the stone?

3. The population (in millions) is given by $P(t) = 0.00005t^2 + 0.01t + 1$, where t is the number of years since 1990.

   a. How large is the population in 1996?

   b. What is the average rate of change of the population from 1990 to 1996?

   c. How fast is the population changing in 1996?

   d. In what year will the population grow at a rate of 12,000 people per year?

4. The temperature T (in degrees Fahrenheit) of a cooling object is given by $T(t) = \frac{3}{4}t^2 - 30t + 340$ where t is in minutes.

   a. How fast is the object cooling over the first 10 minutes (indicate units)?

   b. At what rate does the object cool after 10 minutes (indicate units)?

5. The position (s in feet) of a particle moving in a straight line during a 5 second trip is given by $s(t) = t^2 - t + 10$, where t is in seconds.

   a. What is the average velocity for the entire trip?

   b. At what time will the instantaneous velocity equal the average velocity found it part a)?

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Section 3.1 – Rates of Change; Physics Applications

1. A stone is dropped from a 32 foot building. Its height (in feet) is given by $h(t) = -16t^2 + 32$ where t is in seconds.

   a. How long will it take for the stone to reach the ground?

   $h(t) = 0 \quad -16t^2 + 32 = 0$

   $\boxed{t = \sqrt{2} \approx 1.414}$

   b. What is the average velocity of the stone for the entire trip?

   $\frac{h(\sqrt{2}) - h(0)}{\sqrt{2}} \approx \boxed{-22.627 \text{ FT/s}}$

   c. What is the impact speed of the stone?

   $v(t) = -32t$

   $\boxed{\text{SPEED} = 45.255 \text{ s}}$

   $v(\sqrt{2}) \approx -45.255$

2. A slingshot launches a stone vertically so that the height of the stone is given by the function $h(t) = -16t^2 + 300t + 6$, where h is in feet and t is in seconds.

   a. Find the average velocity of the stone from 0 to 4 seconds.

   $\frac{h(4) - h(0)}{4 - 0} = \boxed{236 \text{ FT/s}}$

   b. Find the velocity of the stone at 4 seconds.

   $v(t) = -32t + 300$

   $\boxed{v(4) = 172 \text{ FT/s}}$

   c. Find the initial velocity of the stone.

   $\boxed{v(0) = 300 \text{ FT/s}}$

   d. How long will it take for the stone to reach its maximum height (HINT: What will the velocity be when the stone reaches its maximum height?)

   $v(t) = 0 \quad -32t + 300 = 0$

   $\boxed{t = 9.375 \text{ s}}$

   e. How high will the stone go?

   $h(9.375) = \boxed{1412.25 \text{ FT}}$

   f. How long after the stone was launched will it take to return to the ground?

   $h(t) = 0 \quad -16t^2 + 300t + 6 = 0$

   $\boxed{t = 18.770 \text{ s}}$

   g. What is the impact velocity of the stone?

   $v(18.770) = \boxed{-300.639 \text{ FT/s}}$

3. The population (in millions) is given by $P(t) = 0.00005t^2 + 0.01t + 1$, where t is the number of years since 1990.

   a. How large is the population in 1996?

   P(6) = 1.0618 million

   b. What is the average rate of change of the population from 1990 to 1996?

   $\frac{P(6) - P(0)}{6 - 0}$ = .0103 million/yr ≈ 10,300 people/year

   c. How fast is the population changing in 1996?

   P'(t) = .0001t + .01

   P'(6) = .0106 million/yr = 10,600 people/yr

   d. In what year will the population grow at a rate of 12,000 people per year?

   P'(t) = .0120

   t = 20

   In 2010

4. The temperature T (in degrees Fahrenheit) of a cooling object is given by $T(t) = \frac{3}{4}t^2 - 30t + 340$ where t is in minutes.

   a. How fast is the object cooling over the first 10 minutes (indicate units)?

   $\frac{T(10) - T(0)}{10 - 0}$ = −22.5 °F/min

   b. At what rate does the object cool after 10 minutes (indicate units)?

   T'(t) = $\frac{3}{2}$t − 30

   T'(10) = −15 °F/min

5. The position (s in feet) of a particle moving in a straight line during a 5 second trip is given by $s(t) = t^2 - t + 10$, where t is in seconds.

   a. What is the average velocity for the entire trip?

   $\frac{s(5) - s(0)}{5 - 0}$ = 4 ft/sec

   b. At what time will the instantaneous velocity equal the average velocity found it part a)?

   v(t) = 2t − 1 = 4

   t = 2.5 s