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19. **Particle Motion** A particle moves along a line so that its position at any time $t \geq 0$ is given by the function

$$s(t) = t^2 - 3t + 2,$$

where s is measured in meters and t is measured in seconds.

- (a) Find the displacement during the first 5 seconds.
- (b) Find the average velocity during the first 5 seconds.
- (c) Find the instantaneous velocity when $t = 4$.
- (d) Find the acceleration of the particle when $t = 4$.
- (e) At what values of t does the particle change direction?
- (f) Where is the particle when s is a minimum?

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71.

Vertical Motion On Earth, if you shoot a paper clip 64 ft straight up into the air with a rubber band, the paper clip will be $s(t) = 64t - 16t^2$ feet above your hand at t sec after firing.

- (a) Find ds/dt and d^2s/dt^2 .
- (b) How long does it take the paper clip to reach its maximum height?
- (c) With what velocity does it leave your hand?
- (d) On the moon, the same force will send the paper clip to a height of $s(t) = 64t - 2.6t^2$ ft in t sec. About how long will it take the paper clip to reach its maximum height, and how high will it go?

72.

Free Fall Suppose two balls are falling from rest at a certain height in centimeters above the ground. Use the equation $s = 490t^2$ to answer the following questions.

- (a) How long does it take the balls to fall the first 160 cm? What is their average velocity for the period?
- (b) How fast are the balls falling when they reach the 160-cm mark? What is their acceleration then?