8. $Q(t) = 200(30-t)^2$

$= 200(900 - 60t + t^2)$

$= 180{,}000 - 12{,}000t + 200t^2$

$Q'(t) = -12{,}000 + 400t$

The rate of change of the amount of water in the tank after 10 minutes is $Q'(10) = -8000$ gallons per minute.

Note that $Q'(10) < 0$, so the rate at which the water is running *out* is positive. The water is running out at the rate of 8000 gallons per minute.

The average rate for the first 10 minutes is

$$\frac{Q(10)-Q(0)}{10-0} = \frac{80{,}000 - 180{,}000}{10} = -10{,}000 \text{ gal/min.}$$

The water is flowing out at an average rate of 10,000 gallons per minute over the first 10 min.

16. Moon:

$s(t) = 0$

$832t - 2.6t^2 = 0$

$2.6t(320 - t) = 0$

$t = 0$ or $t = 320$

It takes 320 seconds to return.

Earth:

$s(t) = 0$

$832t - 16t^2 = 0$

$16t(52 - t) = 0$

$t = 0$ or $t = 52$

It takes 52 seconds to return.

18. **(a)** 190 ft/sec

(b) 2 seconds

(c) After 8 seconds, and its velocity was 0 ft/sec then

(d) After about 11 seconds, and it was falling 90 ft/sec then

(e) About 3 seconds (from the rocket's highest point)

(f) The acceleration was greatest just before the engine stopped. The acceleration was constant from $t = 2$ to $t = 11$, while the rocket was in free fall.

20. **(a)** $v(t) = \frac{ds}{dt} = \frac{d}{dt}(-t^3 + 7t^2 - 14t + 8)$

$v(t) = -3t^2 + 14t - 14$

(b) $a(t) = \frac{dv}{dt} = \frac{d}{dt}(-3t^2 + 14t - 14)$

$a(t) = -6t + 14$

(c) $v(t) = -3t^2 + 14t - 14 = 0$

$t \approx 1.451,\ 3.215$

(d) The particle starts at the point $s = 8$ when $t = 0$ and moves left until it stops at $s = -0.631$ when $t = 1.451$, then it moves right to the point $s = 2.113$ when $t = 3.215$ where it stops again, and finally continues left from there on.

24. $a(t) = v'(t) = 6t^2 - 18t + 12$

Find when acceleration is zero.

$6t^2 - 18t + 12 = 0$

$6(t^2 - 3t + 2) = 0$

$6(t-1)(t-2) = 0$

$t = 1$ or $t = 2$

At $t = 1$, the speed is $|v(1)| = |0| = 0$ m/sec.

At $t = 2$, the speed is $|v(2)| = |-1| = 1$ m/sec.

34. **(a)** $\frac{dV}{dr} = \frac{d}{dr}\left(\frac{4}{3}\pi r^3\right) = 4\pi r^2$

When $r = 2$, $\frac{dv}{dr} = 4\pi(2)^2 = 16\pi$ cubic feet of volume per foot of radius.

(b) The increase in the volume is

$\frac{4}{3}\pi(2.2)^3 - \frac{4}{3}\pi(2)^3 \approx 11.092$ cubic feet.