

Problem The rate of flow of water into an initially empty tank is $100 - 3t$ gallons per minute at time t minutes.

How much water flows into the tank between $t=10$ and $t=20$ minutes?

Soln

Amount
of
water

$$= \int_{10}^{20} (100 - 3t) dt$$

$$= 100t - \frac{3}{2}t^2 \Big|_{10}^{20}$$

$$= 100 \times 20 - \frac{3}{2} 400 - \left(100 \times 10 - \frac{3}{2} 100 \right)$$

$$= 2000 - 600 - 1000 + 150$$

$$= 550 \text{ gallons.}$$



Problem A stone is dropped from a 200 m high cliff. The acceleration due to gravity is 9.8 m/s^2 .

- i) How fast is the stone travelling 5 seconds after being dropped?
- ii) How long does the stone take to reach the ground?

Solⁿ (i) The acceleration $a(t)$ at time t is the rate of change of velocity with respect to time. So at time T , the velocity is

$$v(T) = \int_0^T a(t) dt \quad (*)$$

$$v(s) = \int_0^s 9.8 \, dt$$

$$= 9.8t \Big|_0^s = 49 \, \text{m/s.}$$

Soln (ii)

from (*) the velocity at time T is

$$v(T) = \int_0^T 9.8 \, dt$$

$$= 9.8t \Big|_0^T$$

$$= 9.8T$$

So

$v(t) = 9.8t$ is the formula for velocity at time t .

distance
at time
 T

$$= \int_0^T 9.8t \, dt$$

$$\text{distance (T)} = \frac{9.8 t^2}{2} \Big|_0^T$$

$$= 4.9 T^2 \text{ metres}$$

The time for stone to drop
200 m is got by solving

$$200 = 4.9 T^2$$

$$T = \sqrt{\frac{200}{4.9}} \text{ sec}$$

$$= 10 \sqrt{\frac{2}{4.9}}$$

$$= 6.4 \text{ sec}$$

2. Techniques of Integration

Technique 1: Algebraic Simplification

Problem Find an anti-derivative

$$F(x) = \int (x^2 + 1)(x^4 - 2) dx$$

Solⁿ

$$F(x) = \int (x^6 + x^4 - 2x^2 - 2) dx$$

$$F(x) = \frac{1}{7}x^7 + \frac{1}{5}x^5 - \frac{2}{3}x^3 - 2x + C$$

where C is any constant.

Problem Determine

$$\int \frac{x^3 + x^2 - x - 1}{x-1} dx .$$

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