

Impulse Problems

Concept Review:

A. What is momentum and what are its units?

$$p = mv \quad \text{units: } \text{kg} \cdot \text{m/s}$$

B. What is impulse and what are its units?

$$J = Ft \quad \text{units: } \text{N} \cdot \text{s}$$

"J" → Impulse

C. How are momentum and impulse related to each other?

$$J = \Delta p \quad \rightarrow \text{(often, I just write } Ft = \Delta p)$$

D. What is meant by the phrase "change in momentum?" How about "change in velocity?"

$$\Delta p = p_f - p_i$$

$\uparrow mv_f \quad \quad \uparrow mv_i$

$$\Delta v = v_f - v_i$$

Change in Momentum

1. A 2 kg ball at rest is kicked and has a final velocity of 15 m/s. What was the change in momentum of the ball?

$$m = 2 \text{ kg}$$

$$v_i = 0 \text{ m/s} \quad v_f = 15 \text{ m/s}$$

$$\Delta p = p_f - p_i$$

$$\Delta p = mv_f - mv_i$$

$$\Delta p = (2)(15) - (2)(0)$$

$$\Delta p = 30 \text{ kg} \cdot \text{m/s}$$

2. A 2 kg ball is moving with a velocity of 15 m/s when someone catches it. What is the change in momentum of the ball?

$$m = 2 \text{ kg}$$

$$v_i = 15 \text{ m/s}$$

$$v_f = 0 \text{ m/s}$$

$$\Delta p = p_f - p_i$$

$$= mv_f - mv_i$$

$$\Delta p = (2)(0) - (2)(15)$$

$$\Delta p = -30 \text{ kg} \cdot \text{m/s}$$

3. A 1500 kg car speeds up from 10 m/s to 25 m/s. What is its change in momentum?

$$m = 1500 \text{ kg}$$

$$v_i = 10 \text{ m/s}$$

$$v_f = 25 \text{ m/s}$$

$$\Delta p = p_f - p_i$$

$$= mv_f - mv_i$$

$$\Delta p = (1500)(25) - (1500)(10)$$

$$= 37,500 - 15,000$$

$$\Delta p = 22,500 \text{ kg} \cdot \text{m/s}$$

4. A 1200 kg starts at rest, and undergoes a change in momentum of 20,000 kg·m/s. What is its final velocity?

$$m = 1200 \text{ kg}$$

$$v_i = 0 \text{ m/s}$$

$$\Delta p = 20,000 \text{ kg} \cdot \text{m/s}$$

$$\Delta p = p_f - p_i$$

$$\Delta p = mv_f - mv_i$$

$$20,000 = (1200)v_f - (1200)(0)$$

$$20,000 = 1200v_f$$

$$v_f = 16.7 \text{ m/s}$$

Impulse Problems

5. A 25 kg rock has an initial velocity of 10 m/s. What is its final velocity if its change in momentum was 350 kg•m/s?

$$m = 25 \text{ kg}$$

$$v_i = 10 \text{ m/s}$$

$$\Delta p = 350 \text{ kg m/s}$$

$$\Delta p = p_f - p_i$$

$$\Delta p = mv_f - mv_i$$

$$350 = (25)v_f - (25)(10)$$

$$350 = 25v_f - 250$$

$$600 = 25v_f$$

$$v_f = 24 \text{ m/s}$$

6. A 25 kg rock has an initial velocity of 10 m/s. What is its final velocity if its change in momentum was -350 kg•m/s?

$$m = 25 \text{ kg}$$

$$v_i = 10 \text{ m/s}$$

$$\Delta p = -350 \text{ kg m/s}$$

$$\Delta p = p_f - p_i$$

$$\Delta p = mv_f - mv_i$$

$$-350 = (25)v_f - (25)(10)$$

$$-350 = 25v_f - 250$$

$$-100 = 25v_f$$

$$v_f = -4 \text{ m/s}$$

Impulse

7. A box is pushed with a force of 150 N for 2 seconds. What impulse was exerted on the box?

$$F = 150 \text{ N}$$

$$t = 2 \text{ s}$$

$$J = Ft$$

$$J = (150)(2)$$

$$J = 300 \text{ N}\cdot\text{s}$$

8. A box is pushed with a force of 150 N for 10 seconds. What impulse was exerted on the box?

$$F = 150 \text{ N}$$

$$t = 10 \text{ s}$$

$$J = Ft$$

$$J = (150)(10)$$

$$J = 1500 \text{ N}\cdot\text{s}$$

9. 0.15 kg ball is hit with a force of 170 N for 0.25 seconds. What impulse was exerted on the ball?

$$m = 0.15 \text{ kg}$$

$$F = 170 \text{ N}$$

$$t = 0.25 \text{ s}$$

$$J = Ft = (170)(0.25) = 42.5 \text{ N}\cdot\text{s}$$

the mass doesn't matter! :)

10. How much force is needed to exert an impulse of 50 N•s in 15 seconds? How about in 2 seconds? How about 0.003 seconds?

$$J = 50 \text{ N}\cdot\text{s}$$

$$t = 15 \text{ s}$$

$$J = Ft$$

$$50 = F(15)$$

$$F = 3.3 \text{ N}$$

$$J = Ft$$

$$50 = F(2)$$

$$F = 25 \text{ N}$$

$$J = Ft$$

$$50 = F(0.003)$$

$$F = 16,700 \text{ N}$$

11. How much time is needed for a 4.5 N force to create an impulse of 12 N•s?

$$F = 4.5 \text{ N}$$

$$J = 12 \text{ N}\cdot\text{s}$$

$$J = Ft$$

$$12 = (4.5)t$$

$$t = 2.67 \text{ s}$$

$$J = Ft = \Delta p$$

Impulse Problems

All Together

12. What impulse is needed to make a 2.5 kg ball go from rest to 23 m/s?

$$m = 2.5 \text{ kg}$$

$$v_i = 0 \text{ m/s}$$

$$v_f = 23 \text{ m/s}$$

$$Ft = \Delta p$$

$$Ft = mv_f - mv_i$$

$$Ft = (2.5)(23) - (2.5)(0)$$

$$Ft = 57.5 \text{ Ns}$$

13. What impulse is needed to stop a 0.15 kg egg traveling at 1.3 m/s?

$$m = 0.15 \text{ kg}$$

$$v_i = 1.3 \text{ m/s}$$

$$v_f = 0 \text{ m/s}$$

$$Ft = \Delta p = mv_f - mv_i$$

$$= (0.15)(0) - (0.15)(1.3)$$

$$= -0.195 \text{ Ns}$$

14. A 2.5 kg ball is traveling with a velocity of 20 m/s to the right. What impulse is needed to make the ball move at 20 m/s to the left?

$$m = 2.5 \text{ kg}$$

$$v_i = 20 \text{ m/s}$$

$$v_f = -20 \text{ m/s}$$

$$Ft = \Delta p = mv_f - mv_i$$

$$= (2.5)(-20) - (2.5)(20)$$

$$= -50 - 50$$

$$= -100 \text{ Ns}$$

15. What is the change in momentum of an object if a force of 75 N is exerted on it for 3 seconds?

$$F = 75 \text{ N}$$

$$t = 3 \text{ s}$$

$$Ft = \Delta p$$

$$(75)(3) = \Delta p$$

$$\Delta p = 225 \text{ kg}\cdot\text{m/s}$$

16. A 0.5 kg cart is at rest on a table. An explosion gives the cart a speed of 1.2 m/s in only 0.2 seconds. What was the force on the cart from the explosion?

$$m = 0.5 \text{ kg}$$

$$v_i = 0 \text{ m/s}$$

$$v_f = 1.2 \text{ m/s}$$

$$t = 0.2 \text{ s}$$

$$J = \Delta p$$

$$Ft = mv_f - mv_i$$

$$F(0.2) = (0.5)(1.2) - (0.5)(0)$$

$$F(0.2) = 0.6$$

$$F = 3 \text{ N}$$

Impulse Problems

17. A 1200 kg car traveling is traveling at 30 m/s when it hits the brakes. If the braking force of 2000 N lasts for 7 seconds, what is the final velocity of the car?

$$m = 1200 \text{ kg}$$

$$v_i = 30 \text{ m/s}$$

$$F = -2000 \text{ N}$$

$$t = 7 \text{ s}$$

→ brakes are trying to slow car down, so - Force.

$$J = \Delta p$$

$$F t = m v_f - m v_i$$

$$(-2000)(7) = (1200) v_f - (1200)(30)$$

$$-14,000 = 1200 v_f - 36,000$$

$$22,000 = 1200 v_f$$

$$v_f = 18.3 \text{ m/s}$$

Answers:

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|--------------|---------------------------|------------------|----------------|
| 1) 30 kg•m/s | 2) -30 kg•m/s | 3) 22,500 kg•m/s | 4) 16.7 m/s |
| 5) 24 m/s | 6) -4 m/s | 7) 300 N•s | 8) 1500 N•s |
| 9) 42.5 N•s | 10) 3.3 N, 25 N, 16,700 N | 11) 2.67 s | |
| 12) 57.5 N•s | 13) -0.2 N•s | 14) -100 N•s | 15) 225 kg•m/s |
| 16) 3 N | 17) 18.3 m/s | | |