Momentum, Work and Energy Review

1.5 Momentum

Be able to:

- solve simple momentum and impulse problems
- determine impulse from the area under a force-time graph
- solve problems involving the impulse-momentum equation and the law of conservation of momentum
- relate the impulse-momentum equation to real-life situations

1.6 Work and Energy

Be able to:

- solve simple problems involving work done
- solve simple problems involving various types of energy
    - kinetic
    - gravitational potential
    - spring potential
- determine work done from the area under a force-position graph
- describe work as the transfer of energy
- give examples of various forms of energy and describe how they can do work
- solve problems involving the law of conservation of energy
    - roller coaster
    - compressing a spring
    - ball rolling up or down a hill
    - etc.

Review Problems

1. Two identical automobiles have the same speed, one traveling east and one traveling west. Do these cars have the same momentum? Explain.

2. In movies, Superman hovers stationary in midair, grabs a villain by the neck, and throws him forward. Superman, however, remains stationary. Using the conservation of linear momentum, explain what is wrong with this scene.

3. What is the momentum of a $15\ g$ sparrow flying with a speed of $12\ m/s$? ($0.18\ kg \cdot m/s$)

4. Jim strikes a $0.058\ kg$ golf ball with a force of $272\ N$ and gives it a velocity of $62.0\ m/s$. How long was the club in contact with the ball? ($0.013\ s$)

5. A force of $186\ N$ acts on a $7.3\ kg$ bowling ball for $0.40\ s$.

   a) What is the bowling ball's change in momentum? ($74.4\ N \cdot s$)

   b) What is its change in velocity? ($10.2\ m/s$)

6. A $5500\ kg$ freight truck accelerates from $4.2\ m/s$ to $7.8\ m/s$ in $15.0\ s$ by applying a constant force.

   a) What change in momentum occurs? ($19800\ kg \cdot m/s$)

   b) How large of a force is exerted? ($1320\ N$)

7. A $0.145\ kg$ baseball is pitched at $42\ m/s$. The batter hits it horizontally to the pitcher at $58\ m/s$.

   a) Find the change in momentum of the ball. ($-14.5\ kg \cdot m/s$)

   b) If the ball and bat were in contact $4.6 \times 10^{-4}\ s$, what would be the average force while they touched? ($-31522\ N$)

8. A $550\ kg$ car traveling at $24.0\ m/s$ collides head-on with a $680\ kg$ pickup truck. Both vehicles come to a complete stop upon impact.

   a) What is the momentum of the car before the collision? ($13200\ kg \cdot m/s$)

   b) What is the change in momentum of the car? ($-13200\ kg \cdot m/s$)

   c) What is the change in momentum of the truck? ($13200\ kg \cdot m/s$)

   d) What is the velocity of the truck before the collision? ($-19.4\ m/s$)

9. A $50.0\ g$ projectile is launched with a horizontal velocity of $647\ m/s$ from a $4.65\ kg$ launcher moving in the same direction at $2.0\ m/s$. What is the velocity of the launcher after the projectile is launched? ($-4.94\ m/s$)

10. Two lab carts are pushed together with a spring mechanism compressed between them. Upon release, the $5.0\ kg$ cart repels one way with a velocity of $0.12\ m/s$ while the $2.0\ kg$ cart goes in the opposite direction. What velocity does it have? ($-0.3\ m/s$)

11. A $12.0\ g$ rubber bullet travels at a velocity of $150\ m/s$, hits a stationary $8.5\ kg$ concrete block resting on a frictionless surface, and ricochets in the opposite direction with a velocity of $-100\ m/s$. How fast will the concrete block be moving? ($0.35\ m/s$)

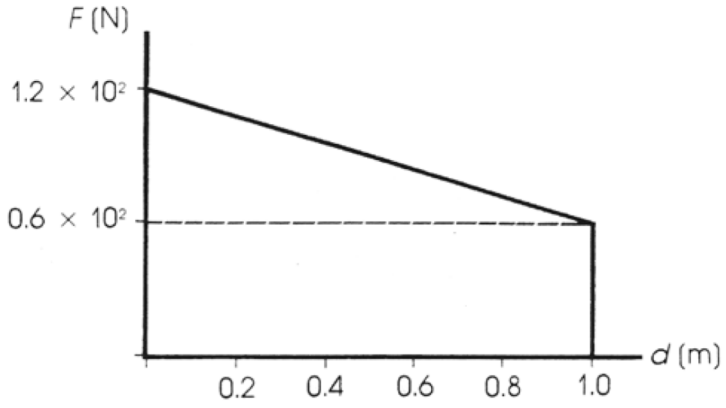
12. During a tug-of-war, Team A does $220000\ J$ of work in pulling Team B $8.0\ m$. What force was Team A exerting? ($27500\ N$)

13. A weightlifter raises a $180\ kg$ barbell to a height of $1.95\ m$. How much work was done by the weightlifter in lifting the barbells? ($3440\ J$)

14. A wagon is pulled by a force of $38.0\ N$ on the handle at an angle of $42°$ with the horizontal. If the wagon is pulled in a circle of radius $25.0\ m$, how much work is done? ($4436\ J$)

15. A $185\ kg$ refrigerator is loaded into a moving van by pushing it up a $10.0\ m$ ramp at an angle of inclination of $11°$. How much work is done? ($3459\ J$)

16. A pellet of mass $5.0\ g$ is fired from a heavy gun whose barrel is $100\ cm$ long. The force on the pellet while it is in the barrel is given by the graph below. What is the velocity of the pellet as it leaves the barrel? ($189.7\ m/s$)



17. A force of $30.0\ N$ pushes a $1.5\ kg$ cart, initially at rest, a distance of $2.8\ m$ along a frictionless surface.

    a) Find the work done on the cart. ($84\ J$)

    b) What is the change in kinetic energy? ($84\ J$)

    c) What is the cart's final velocity? ($10.6\ m/s$)

18. A bike and rider, $82\ kg$ combined mass, are traveling at $4.2\ m/s$. A constant force of $-140\ N$ is applied by the brakes in stopping the bike. What braking distance is needed? ($5.2\ m$)

19. A $712\ kg$ car is traveling at $5.6\ m/s$ when a force acts on it for $8.4\ s$, changing its velocity to $10.2\ m/s$.

    a) What is the change in kinetic energy of the car? ($25874\ J$)

    b) How far did the car move while the force acted? ($66.4\ m$)

    c) How large is the force? ($390\ N$)

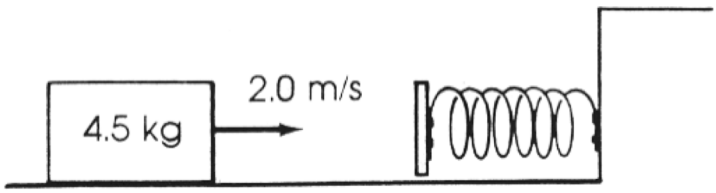
20. Five identical $0.85\ kg$ books of $2.50\ cm$ thickness are each laying flat on a table. Calculate the gain in potential energy of the system if they are stacked one on top of the other. ($2.1\ J$)

21. A 1.0 kg lead sphere is suspended from the ceiling by a wire 5.0 m long. The ball is pulled sideways and up, until the wire is horizontal, and then released. Find:

    a) the maximum velocity acquired by the ball. (9.9 m / s)

    b) the tension in the wire at the lowest point in the swing. (29.4 N)

22. A linear elastic spring can be compressed 10.0 cm by an applied force of 5.0 N . A 4.5 kg crate of apples, moving at 2.0 m / s , collides with this spring, as shown below. What will be the maximum compression of the spring? (0.60 m)



23. A 15 kg model plane flies horizontally at a constant speed of 12.5 m / s .

    a) Calculate its kinetic energy. (1172 J)

    b) The plane goes into a dive and levels off 20.4 m closer to Earth. How much potential energy does it lose during the dive? Assume no additional drag.
    ($-2999\ J$)

    c) How much kinetic energy does the plane gain during the dive? ($+2999\ J$)

    d) What is the new kinetic energy? (4171 J)

    e) What is the new horizontal velocity? (23.6 m / s)

24. A 1200 kg car starts from rest and accelerates to 72 km/h in 20.0 s. Friction exerts an average force of 450 N on the car during this time.

    a) What is the net work done on the car? (240000 J)

    b) How far does the car move during its acceleration? (200 m)

    c) What is the net force exerted on the car during this time? (1200 N)

    d) What is the forward force exerted on the car as a result of the engine, power train, and wheels pushing backward on the road? (1650 N)

25. Suppose the roller coaster car in the figure below has a velocity of 1.8 m/s at point A and moves without friction. How fast is it going at points B, C, and D? (24.3 m/s, 10.1 m/s, 18.9 m/s)