Supplementary Exercise - Momentum and Impulse (Certificate level) S____( ) Name: _____
Take g = 10 ms^{-2}

1. Find the momentum of the objects below. (Take forward as positive)
   a) 5 kg moving at a velocity of 4 m s^{-1} forward
   b) 6 kg moving at a velocity of 5 m s^{-1} backward

2. A mass of 2 kg undergoes free fall. What is its linear momentum after it has fallen a distance of 5m ?

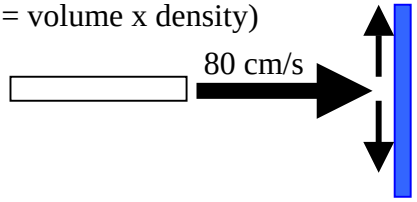
3. While waiting in his car before a traffic lamp, an 80-kg man and his car are suddenly accelerated to a speed of 5 m/s as the result of a rear-end collision. Assuming the time taken to be 0.25 s, find (a) the impulse on the man and (b) the average force exerted on him by the back of the seat of his car.

4. A 2.0 kg block slides on a frictionless horizontal surface, first moving to the left at 50 m/s. It collides with a spring as it moves left, compresses the spring, and is brought to rest momentarily. Then the body continues to be accelerated to the right by the force of the compressed spring. Finally, the body moves to the right at 40 m/s. The block remains in contact with the spring for 0.02s. a) What were the magnitude and direction of the impulse of the spring on the block? b) What was the spring's average force on the block?

5. A golfer hits a golf ball of mass 50 g . The ball leaves the club with a velocity of 80 m/s. Assuming that the ball and club are in contact for 0.006 s, find the ball's final momentum and the average force exerted by the club on the ball.

6. A 5.0 g bullet moving at 100 m/s strikes a wooden block. Assume that the bullet undergoes uniform deceleration and stops in 6.0 cm. Find (a) the time taken for the bullet to stop, (b) the impulse on the wooden block, and (c) the average force experienced by the wooden block.

7. **What force is exerted on a stationary flat plate held perpendicular to a jet of water as shown in the figure? The horizontal speed of the water is 80 cm/s and 30 cm^3 of the water hits the plate each second. Assume that the water moves parallel to the plate after striking it. (Density of water: one cubic centimeter of water has a mass of one gram or 1g/cm^3. Mass = volume x density)



8. **What force is exerted on a high-rise building of 60 m high and 25 m wide if a wind with velocity of 4m/s is stopped by the building? (Density of air is about 1.25 kg/m^3.)

9. A ball of 0.4 kg mass and a speed of 3 m/s has a head-on, completely elastic collision with a 0.6-kg mass initially at rest. Find the speeds of both bodies after the collision.

10. A proton of mass 1.66×10^{-27} kg collides head-on with a helium atom at rest. The helium atom has a mass of 6.64×10^{-27} kg and recoils with a speed of 5×10^{5} m/s. If the collision is elastic, what are the initial and final speeds of the proton and the fraction of its initial energy transferred to the helium atom?

11. Two perfectly elastic balls, one weighing 1 kg and the other 1.5 kg, are moving in opposite directions with speeds of 3 and 2.5 m/s, respectively. Find their velocities after head-on impact.

12. Two identical balls collide head-on. The initial velocity of one is 0.75 m/s, while that of the other is -0.43 m/s. If the collision is perfectly elastic, what is the final velocity of each ball?

13. A 0.5 kg ball moving to the right at 4 m/s collides head-on with a 1 kg ball moving at 4 m/s in the opposite direction. If the two balls stick together after the collision, what is (a) their total momentum after the collision; (b) their final velocity , including the direction?

14. An 8-g bullet if fired horizontally into a 9-kg block of wood and sticks in it. The block, which is free to move, has a velocity of 40 cm/s after impact. Find the initial velocity of the bullet.

15. A 16 g mass is moving in the +x direction at 30 cm/s while a 4-g mass is moving in the -x direction at 50 cm/s. They collide head-on and stick together. Find their velocity after collision.

16. A 2-kg rock is moving at a speed of 6 m/s. What constant force is needed to stop the rock in $7x10^{-4}$ s?

17. A 20-g bullet moving horizontally at 50 m/s strikes a 7-kg block resting on a table. The bullet embeds in the block after collision. Find (a) the speed of the block after collision and (b) the frictional force between the table and block if the block moves 1.5 m before stopping.

18. Suppose that a horizontal force of 0.70 N is required to pull a 5-kg block across a table at constant speed. What is the speed of a 20-g bullet, if the bullet embeds in the block and causes the block to slide 1.50 m before coming to rest?

19. A 15-g bullet is fired horizontally into a 3-kg block of wood suspended by a long cord. The bullet sticks in the block. Compute the velocity of the bullet if the impact causes the block to swing 10 cm above its initial level.

20. A 5-g bullet going 300 m/s strikes a 1.995 kg wooden block which is the bob of a pendulum. Find the speed at which block and bullet leave the equilibrium position and the height which the center of gravity of the bullet-block system reaches above the initial position of the center of gravity.

21. A 4-g bullet is fired into a 2.996-kg block of wood which is the bob of a pendulum. If the bob leaves its equilibrium position with a speed of 0.5 m/s, what are the speed of the bullet and the height above the equilibrium position reached by the center of gravity of the block?

22. A 20-g bullet is fired horizontally with a speed of 600 m/s into a 7-kg block sitting on a tabletop; the bullet lodges in the block. If the friction between the block and the tabletop is about 0.4 of the weight of the block, what is the distance the block will slide?

23. A 3-g bullet with a speed of 300 m/s passes right through a 400-g block suspended on a long cord. The impulse gives the block a speed of 1.5 m/s. Find (a) the speed of the bullet after it has passed through the block , (b) the distance which the center of mass rises as the block swings upward after the bullet passes through, (c) the work done by the bullet in passing through the block, and (d) the mechanical energy converted into heat.

24. A 2.0-kg block rests over a small hole on a table. A 15.0-g bullet is shot through the hole into the block, where it lodges. How fast was the bullet going if the block rises 1.30 m above the table ?

Answer 1.
a) p = mv = 5 kg x 4 m/s = 20 kg m/s
b) p = mv = 6 kg x (-5) = -30 kg m/s

Answer 2.
Since 2 a s = v^2 - u^2 , v = 10 m/s,
Its momentum p = m v = 2 x 10 = 20 kg m/s

Answer 3.
a) Ft = mv - mu = 80 x 5 - 80 x 0= 400 N s ,
b) F = (mv-mu)/t = 400 / 0.25 = 1600 N

Answer 4.
a) F t = mv - mu = 2(40) - 2 (-50) = 180 Ns
b) F = 180/0.02 = 9000 N (to the right)

Answer 5.
a) Final momentum : mv = 0.05 kg x 80 m/s = 4 kg m/s
b) average force = 4 / 0.006 = 667 N

Answer 6.
a) s = (v+u) x t /2
0.06 = (0+100) x t/2
t = 0.0012 s
b) impulse on the wooden block = - impulse on the bullet = -[0.005 x 0 - 0.005(100)] = 0.5 kg m/s
c) F = impulse/time = 0.5 / 0.0012 = 417 N

Answer 7.
Mass of water per second = 30 cm^3 x 0.001 kg/cm^3 = 0.03 kg
F = (mv-mu)/t = (v-u) m/t = (0-0.80) x 0.03 = -0.024 N (This is the force acting on the water.)
(The force acting on the plate will be 0.024 N but in opposite direction.)

Answer 8.
Area of the building = 60m x 25m = 1500 m^2
Mass of the air in one second = 1500 x 4 x 1.25 = 7500 kg/s
F = - (mv-mu)/t = (v-u) m/t = - [0-(4)] 7500 = 30000N

Answer 9.
Total p before collision : 0.4 x 3 + 0 = 1.2 Ns
Total p after collision : 0.4 v_1 + 0.6 v_2 = 1.2 ---- (1)
Since u_1-u_2 = - (v_1-v_2) (for elastic collision only)
3 - 0 = -v_1 +v_2 ----(2)
Solve (1) and (2) , v_1 = -0.6 m/s , v_2 = 2.4 m/s

Answer 10.
Use the same concept as in the previous answer.
u_1 = 1.25 x 10^6 m/s
v_1 = -7.5 x 10^5 m/s
Energy fraction = KE of He/ initial KE = 0.6

Answer 11.
Use the same concept as in the previous answer.
v_1 = -3.6 m/s, v_2= 1.9 m/s

Answer 12.
Use the same concept as in the previous answer.
v_1 = -0.43 m/s, v_2= 0.75 m/s

Answer 13.
a) Total momentum after collision = Total momentum before collision = 0.5x 4-1x 4=-2 kg m/s
b) (m_1+m_2) v = -2

v = -2/(0.5+1) = -1.33 m/s
Answer 14. 0.008 x u + 0 = (9+0.008) x 0.4 u = 450 m/s
Answer 15. v = 0.14 m/s
Answer 16. F = -17100N
Answer 17. a) v = 0.142 m/s b) f x s = K.E. (All energy is used to overcome the workdone by firction) f x 1.5 = 0.5 x(7+0.02) x 0.142^2 f = 0.047N
Answer 18. u=162 m/s
Answer 19. u=284m/s
Answer 20. h=0.0281 m , or 2.81 cm
Answer 21. h = 0.0125 m or 1.25 cm
Answer 22. s = 0.365 m
Answer 23. a) v = 100 m/s b) h = 0.1125 m or 1.13 cm c)energy loss by the bullet = 120 J d) Energy converted to heat =119.55 J
Answer 24. u= 684 m/s

All answers are uncorrected[1]

[1] If there is any mistake in the answer, please kindly notify Mr. Yu for modification