**Impulse and Momentum**

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|  | Momentum |
| 12190 kg m/s | 1. What is the momentum of a 23 kg cannon shell going 530 m/s? |
| 4.8 m/s | 2. What speed must a 5 kg object go to have 24 kg m/s of momentum? |
| .066 kg | 3. A bullet going 640 m/s has 42 kg m/s of momentum. What is its mass? |
|  | Impulse |
| 7.8 Ns | 4. What is the impulse imparted by a rocket that exerts 4.8 N for 1.63 seconds? |
| .36 s | 5. For what time must you exert a force of 45 N to get an impulse of 16 Ns? |
| 10.7 N | 6. What force exerted over 6 seconds gives you an impulse of 64 Ns? |
|  | Impulse and Momentum |
| 10.3 m/s | 7. What is the change in velocity of a .35 Kg air track cart if you exert a force of 1.2 N on it for 3 seconds? |
| 119 kg | 8. A rocket engine exerts a force of 500 N on a space probe (in outer space!) for 5 seconds. The probe speeds up from rest to a speed of 21 m/s. What is its mass? |
| 360 N | 9. What force exerted for .12 seconds will make a .54 Kg baseball change its velocity 80 m/s? |
| .71 s | 10. What time must the space probe in question 8 fire its engines to change its velocity by 3 m/s? |
|  | Rocket Propulsion |
| 3040 N  3.95 s  19.7 kg | 11. A rocket engine burns 5 kg of fuel per second. The exhaust gas velocity is 608 m/s. What is the thrust of the engine? What time must it burn to impart an impulse of 12,000 Ns? How much fuel will it burn to do this? |
| 880 m/s | 12. An 11 Ns rocket engine has 12.5 grams of fuel. What is the exhaust velocity? |
| .02 kg/s  6 kg | 13. A rocket generates 25 N of thrust, and the exhaust gas velocity is 1250 m/s. At what rate does it consume fuel in kg/s? How much fuel has it burned in 5 minutes? |
| 180.8 s  2.63 m/s/s  7.73 m/s/s | 14. A small rocket probe in deep space has a mass of 68.5 kg, 45.2 kg of which is fuel. Its engine consumes .250 kg of fuel per second, and it has an exhaust velocity of 720 m/s. For how much time will the engine burn? What is the initial acceleration of the rocket engine? What is the acceleration just before it runs out of fuel? |
| 140 s  75 kN  5.2 m/s/s  40.2 m/s/s | 15. A rocket takes off from the surface of Earth straight up. The total mass of the rocket is 5000 kg, 3500 kg of which is fuel. The exhaust gas velocity is 3000 m/s, and the rocket consumes 25 kg of fuel per second. For how long do the engines burn? What is the thrust of the engine? What are the initial and final accelerations of the rocket? (Don't forget gravity!) |

**Conservation of Momentum**

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| 2.89 m/s | 1. A 1200 Kg car going 13 m/s collides with a 4200 Kg truck at rest. Their bumpers lock. What is their speed afterwards? |
| -.125 m/s | 2. A 60 Kg person running 3 m/s collides head on with a 100 Kg person running -2 m/s (The other way) What is their final velocity if they stick together? |
| -.35 m/s | 3. A 50 Kg ice skater at rest throws a 5 Kg shot put at a velocity of 3.5 m/s. What is the recoil velocity of the skater? |
| 11 m/s | 4. A 1200 Kg car going 15 m/s rear-ends with a 800 Kg car going 5 m/s in the same direction. Their bumpers lock. What is their speed afterwards? |
| 43.8 m/s | 5. A 2000 Kg airplane going 45 m/s fires a 2 Kg shell forward at a speed of 1200 m/s. What is the final velocity of the plane? (Planes crashed because of this!) |
| .629 m/s | 6. A 14.5 g bullet traveling 783 m/s horizontally strikes an 9.24 Kg block of wood at rest on a level frictionless table. The bullet goes through the block, but is traveling only 382 m/s in the same direction after the collision. What is the velocity of the block after the collision? (Assume the block loses no mass) |
| 5.4 m/s | 7 Bumper car A (326 Kg) with velocity 3.7 m/s collides with the rear of car B (536 Kg) which has a velocity of 2.4 m/s in the same direction. After the collision, car A has a velocity of -1.2 m/s. What is the velocity of car B after the collision? |