

Assignment 4

1. A uranium atom at rest disintegrates into two fragments. An alpha particle (helium nucleus) is measured to have a speed of 3×10^5 m/sec. What is the speed of the recoiling atom?
2. A 2 kg mass travelling at 3 m/sec collides and sticks with a 5 kg mass. What is the resultant speed of the combined mass particle?
3. A rocket is propelled as a result of the very rapid ejection of exhaust gas from the rear of the rocket. Given that the initial mass of the rocket and fuel is 5000 kg and that 4000 kg of fuel is burned in accelerating the rocket to a speed of 600 m/sec, calculate the velocity of the exhaust gases.
4. A 1000 kg car travelling at 36 km/hr strikes a tree and comes to rest in 0.1 sec.
 - a) Calculate the order of magnitude of the force exerted by the tree on the car.
 - b) What mass has a weight of the same order of magnitude as the force calculated in a).
 - c) Would it be comforting if an object of this mass sat on you?
5. A rubidium atom travelling at the speed of sound absorbs photons from an oncoming laser beam. Each photon can be viewed as a tiny ping pong ball having momentum 7.79×10^{-28} Nt/sec. The atom absorbs a photon which is then reradiated in any direction. Hence, on average each photon absorption/reemission reduces the atom's momentum by a photon momentum.
 - a) How many photons must an atom absorb and reradiate in order to be stopped?
 - b) What is the deceleration experienced by the atom if it can absorb and reradiate a photon every 2.5×10^{-8} sec?
 - c) What distance does it take to stop an atom?
 - d) How many photons/sec are required to stop a beam of 10^9 atoms/sec?
6. A 1 kg hockey puck moving at 0.5 m/sec strikes another puck having a mass at 2 kg such that the 2 kg puck travels at an angle 45° with a speed of 0.10 m/sec with respect to the motion of the original puck.
 - a) What is the final speed of the first puck?
 - b) What is the final direction of the first puck?

7. A weightlifter raises 250 kg from the floor to a height of 2 meters.
- How much work does he do if:
 - the object is raised straight up
 - the object is first raised one meter straight up, then sideways 3.5 meters to the left followed by another meter straight up and finally 3.5 meters to the right
 - The mass is then released. What is the velocity of the mass when it hits the weightlifter's toe?
8. A neutron of mass 1.67×10^{-24} gm travelling at a speed of 10^5 m/sec collides head on with a stationary deuteron with a mass of 3.34×10^{-24} g. The collision is elastic and the particles do not stick together. Calculate the speed of each after the collision.
9. A 2 gm ball travelling 5 cm/sec hits a 3 gm ball and sticks to it.
- What is the velocity of the combined 5 gm ball?
 - What is the kinetic energy before the collision?
 - What is the kinetic energy after the collision?
 - Can you suggest what happened to the energy?
10. A projectile of mass 20 kg. is projected vertically upward with an initial speed of 50 m/sec
- What is the original kinetic energy?
 - What is the kinetic energy after 2 sec?
 - What is the change in its gravitational energy during these 2 sec?
11. The Canadian Space Agency wishes to launch a rocket.
- What is the escape velocity of the rocket if it is launched from the Earth?
 - Repeat a if the rocket is launched from the surface of the moon.
12. The gravitational potential energy is given by $U = -GmM_E/r$. However, for masses close to the Earth's surface $U = mgh$. Are these formulae consistent? Hint: Substitute $r = R_E + h$, where $h \ll R_E$.