2.1 - Newtons Laws of Motion

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- (1998) State Newton's laws of motion.
- (1998) A ball of mass 0.4 kg is dropped vertically from a height of 2.5 m on to a horizontal table and bounces to a height of 1.5 m.
  - Find the kinetic energy of the ball just before striking the table.
  - Find the kinetic energy just after impact.
  - Suggest reasons for the difference between these two values of kinetic energy.
  - What height would you expect the ball to reach after its next bounce from the table?
- (1998) A jet of water flowing with a velocity of 20 ms^{-1} from a pipe of cross-sectional area, 5.0×10^{-3} m^2 , strikes a wall at right angles and loses all its velocity.
  - What is the mass of water striking the wall per second?
  - What is the change in momentum per second of the water hitting the wall?
  - What is the force exerted on the wall?
- (1999) Define momentum
- (1999) Define impulse of a force
- (1999) A jet of water emerges from a hose pipe of a cross-sectional area 5.0×10^{-3} m^2 with a velocity of 3.0 m/s and strikes a wall at right angle. Assuming the water to be brought to rest by the wall and does not rebound, calculate the force on the wall.
- (1999) Distinguish between static and dynamic friction.
- (2007) A ball is thrown towards a vertical wall from a point 2 m above the ground and 3 m from the wall. The initial velocity of the ball is 20 m/s at an angle of 30 deg above the horizontal. If the collision of the ball with the wall is perfectly elastic, how far behind the thrower does the ball hit the ground?
- (2007) Explain why when catching a fast moving ball, the hands are drawn back will the ball is being brought to rest.
- (2007) Rockets are propelled by the ejection of the products of the combustion of fuel. Consider a rocket of total mass M travelling at a speed v in a region of space where the gravitational forces are negligible.

- (2007) Supposing the combustion products are ejected at a constant speed v, relative to the rocket, show that a fuel "burn" which reduces the total mass M of the rocket to m results in an increase in the speed of the rocket to v such that $v - V = V_f \ln(M/m)$.
- (2007) Supposing that 2.1×10^6 kg of fuel are consumed during a "burn" lasting 1.5×10^2 seconds and given that there is a constant force on the rocket of 3.4×10^7 N during this burn, calculate v, and increase in speed resulting from the burn if $M = 2.8 \times 10^6$ kg.
- (2007) What is the initial vertical acceleration that can be imparted to this rocket when it is launched from the Earth if the inititial mass is 2.8×10^6 kg?
- (2007) State and define Newtons 2nd law of motion with respect to angular motion.
- (2013) A man stands in a lift which is being accelerated upwards at 3.2 m/s^2 . If the man has a mass of 65 kg, what is the net force exerted on the man by the floor of the lift?
- (2013) A rubber cord of a $Y-$ shaped object has a cross sectional area of 4×10^{-6} m^2 ? And relaxation length of 100 mm. If the arms of the catapult are 70 mm apart, calculate the:
  - tension in the rubber.
  - force required to stretch it when the rubber cord is pulled back until its length doubles.
- (2014) State the principle of conservation of linear momentum.
  - Give two examples of the principle of conservation of linear momentum.
- (2014) An insect is released from rest at the top of the smooth bowling ball such that it slides over the ball. Prove that it will loose its footing with the ball at an angle of about 48° with the vertical.
- (2014) A vertical spring fixed at one end has a mass of 0.2 kg and is attached at the other end.
  - Determine the:
  - Extension of the spring.
  - Energy stored in the spring.
- (2014) Define torque and give its S.I. unit.
- (2014) Give two ways in which the internal energy of the system can be changed.
- (2016) State the principles on which the rocket propulsion is based.
- (2016) A jet engine on a test bed takes in 40 kg of air per second at a velocity of 100 m/s and burns 0.80 kg of fuel per second. After compression and heating the exhaust gases are ejected at 600 m/s relative to the air craft. Calculate the thrust of the engine.
- (2016) An object of mass 2 kg is attached to the hook of a spring balance which is suspended vertically to the roof of a lift. What is the reading on the spring balance when the lift is:
  - going up with the rate of 0.2 m/s^2
  - going down with an acceleration of 0.1 m/s^2
  - ascending with uniform velocity of 0.15 m/s

- (2016) Define the term inertia.
- (2017) A 75 kg hunter fires a bullet of mass 10 g with a velocity of 400 m/s from a gun of mass 5 kg. Calculate the:
  - Recoil velocity of the gun.
  - Velocity acquired by the hunter during firing.
- (2017) A traffic light is suspended with two steel wires of equal lengths and radii of 0.5 cm. If the wires make an angle of 15° with the horizontal, what is the fractional increase in their length due to the weight of the light?
- (2018) Under what condition a passenger in a lift feels weightless?
- (2018) Calculate the tension in the supporting cable of an elevator of mass 500 kg which was originally moving downwards at 4 m/s and brought to rest with constant acceleration at a distance of 20 m.
- (2018) The rotating blades of a hovering helicopter swept out an area of radius 2 m imparting a downward velocity of 8 m/s of the air displaced. Find the mass of a helicopter.
- (2019) A rocket of mass 20 kg has 180 kg of fuel. If the exhaust velocity of the fuel is 1.6 km/sec, calculate;
  - The minimum rate of fuel consumption that enable the rocket to rise from the ground.
  - The ultimate vertical speed gained by the rocket when the rate of fuel consumption ts 2 kg/sec.
- (2019) Determine the least number of pieces required to stop the bullet if a rifle bullet loses 1/20 of its velocity when passing through them.
- (2019) A man of 100 kg jumps into a swimming pool from a height of 5 m. If it takes 0.4 seconds for the water in a pool to reduce its velocity to zero, what average force did the water exert on the man?