Problems

Impulse, Momentum & Conservation
Elastic, Kinetic & Gravitational Potential Energy

TIPS & HINTS FOR SOLUTIONS:
PART B PART C

PART A

1. The force acting on a tennis ball (m=0.06 Kg) as a function of time is given by the equation $F(t) = 2t^2 - t$.
a) Use graphical techniques to estimate the total impulse given to the ball by the racket.
b) Determine the speed of the ball after the impact with the racket. Assume that the ball is initially at rest and that the collisions lasts 0.08 s/

2. A 10 g bullet traveling at 400 m/s penetrates a 2.0 Kg block of wood (initially at rest on a frictionless surface) and emerges at 350 m/s. How fast will the block of wood move after the bullet emerges from its opposite end?

3. A neutron collides elastically with a He nucleus at rest. The mass of the He nucleus is four times greater than that of the neutron.
The He nucleus is observed to rebound at 45^0. Determine the angle of rebound of the neutron and the speed of the two particles after the collision.
The initial speed of the neutron is 4.5×10^5 m/s.

4. Three spheres of radius Ro, 2Ro, and 3 Ro are placed side by side (in contact) with their centers along a straight line. Where is the c.m of this system? The radius of the central sphere is 2Ro.

PART B

1. A spring is suspended from a ceiling and a 256-g mass is attached to it and pulled down to stretch the spring by 18.2 cm. The mass is released and travels through the equilibrium position with a speed of 0.746 m/s. Calculate the force constant of the spring. [31.9 N/m]

2. A toy gun fires a 9.41-g projectile disc by using a compressed spring ($k = 1.72 \times 10^3$ N/m) and a 13.1 cm long barrel. As the disc travels through the barrel, it experiences a constant frictional force of 0.13 N. If the spring is compressed 14 mm, what is the speed of the disc as it leaves the gun? [1.8 m/s]

3. An 87-g box is attached to a spring with a force constant of 82 N/m. The spring is compressed 11 cm and the system is released. [2.6 m/s & 3.4 m/s]

(a) What is the speed of the box when the spring is stretched by 7.0 cm?

(b) What is the maximum speed of the box?

4. Calculate the value of the gravitational field strength g, 250 km above the surface of Earth. [9.1 N/m]

5. Calculate the speed of a satellite in orbit 9.5×10^3 km above Jupiter. ($r_J = 7.18 \times 10^7$ m, $M_J = 1.90 \times 10^{27}$ kg). [3.9×10^4 m/s]

6. How far above the surface of Earth does an object need to be so that it weighs half as much as it would normally? [2.64×10^6 m]

7. How fast must a satellite leave Earth's surface to reach an orbit with an altitude of 895 km?
[8.38×10^3 m/s]

8. Mercury has a radius of 2.57×10^6 m and an escape speed of 4.13 km/s. What is the mass of Mercury? [3.29×10^{23} kg]

9. A spring with a force constant of 89 N/m is compressed 8.7 cm and placed between two stationary dynamics carts of mass 1.0 kg and 1.5 kg. If friction is negligible, determine the final speed of the more massive cart when the spring is released. [0.42 m/s]

10. A 34-g bullet travelling at 120 m/s embeds itself in a wooden block on a smooth surface. The block then slides toward a spring and collides with it. The block compresses the spring ($k = 99$ N/m) a maximum of 1.2 cm. Calculate the mass of the block of wood. [12 kg]

11. A 0.40-kg cue ball makes a glancing blow to a stationary 0.30-kg billiard ball so that the cue ball deflects with a speed of 1.2 m/s at an angle of 30.0º from its original path. Calculate the original speed of the cue ball if the billiard ball ends up travelling at 1.5 m/s. [2.0 m/s]

12. A small explosive charge is placed in a rubber block resting on a smooth surface. When the charge is detonated, the block breaks into three pieces. A 200-g piece travels at 1.4 m/s, and a 300-g piece travels at 0.90 m/s. The third piece flies off at a speed of 1.8 m/s. If the angle between the first two pieces is 80º, calculate the mass and direction of the third piece. Assume two significant digits for each value.
[m = 0.23 kg at an angle of 141^0 from the 200 g piece]

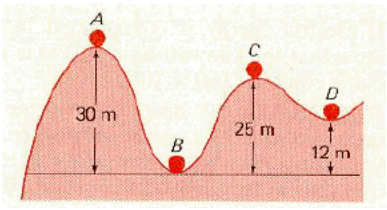
13. A 38-g bullet is fired with a speed of 180 m/s into a 5.0-kg sandbag pendulum that is free to swing. To what maximum vertical height will the pendulum rise? [9.4 cm up]

PART C: Angular Momentum & Power

1. What is the angular momentum of a 200 g ball rotating on the end of a string in a circle of radius 1.00 m at an angular speed of 9.45 rad/s? [1.89 kg m^2 /s]

2 A person stands, hands at the side, on a platform that is rotating at 1.2 rev/s. If the person raises her arms to a horizontal position the speed of rotation slows down to 0.80 rev/s. Explain why this happens and calculate the % change in the moment of inertia. [150%]

3. A roller coaster is shown in the diagram below. Assuming no friction, calculate the speeds at points B, C, D if the speed at point A is 2.10 m/s. [24.3 m/s; 10.1 m/s; 18.9 m/s]



4. If a car generates 15 hp when travelling at a steady 80 km/h, what must be the average force exerted on the car due to friction and air resistance? [507 N]

5. How long will it take a l500-W motor to lift a 400-kg piano to a sixth-story window 32.0 m above?
[83.6 s]

6. Electric energy is often stated in kilowatt-hour! Show that the kilowatt-hour (kWh) is a unit of energy and is equal to 3.60 x 10^6 J. [hint: 1kWh = 1000 W * 3600 s]

7. A 1200-kg car slows down from 90 km/h to 70 km/h in about 5.0 s on the level when it is in neutral Approximately what power (watts and hp) is needed to keep the car travelling at a constant 80 km/h?
[2.98 x 10^4 W or 39.7 hp]

8. A shot-putter accelerates a 7.3-kg shot from rest t 15 m/s. If this motion takes 2.0 s, what average power was developed? [411 W]

9. How much work can a 2.0-hp motor do in 1.0 h ? [5.4 x 10 ^{6} J]

10. A 70-kg hiker climbs to the top of a 4200-m high mountain. The climb is made in 4.0 h starting at an elevation of 3200 m. Calculate (a) the work done against gravity, (b) the average power output in watts and in horsepower, and (c) assuming the body is 15 percent efficient, what rate of energy input was required. [6.86 x 10 ^{5}J; 47.6 W; 0.0635 hp; 317 W]

11. How fast must a cyclist climb a 12.5° hill to maintain a power output of 0.23 hp? Ignore friction and assume the mass of cyclist plus bicycle is 85 kg. [0.957 m/s]

12. A pump is to lift 4.10 kg of water per minute through a height of 2.85 m. What output rating (watt! should the pump motor have? [1.91 W]