

Physics 2A 2nd Midterm (200 Points MAX)

Summer 2004

Show your work with diagrams, explanations, and clear writings. No credit will be given for answers without diagrams, explanations, and clear writings.

- (a) A Boeing 747 airliner, weighing 2.2×10^6 N (i.e., 5.0×10^5 lb) at takeoff, is cruising at a ground speed of 268 m/s (i.e., 600 mi/h). Compute its kinetic energy. If 1 kg of TNT yields 4.6×10^6 J, how much TNT is the plane's KE equivalent to?

(b) A 50-kg keg of beer slides upright down a 3.0-m-long plank leading from the back of a truck 1.5 m high to the ground. Determine the amount of work done on the keg by gravity.
- (a) What is the kinetic and potential energy of a Boeing 747 airliner weighing 2.22×10^6 N, flying at 268 m/s (i.e., 600 mi/h) at an altitude of 6.1 km (i.e., 20×10^3 ft)?

(b) A 10.0-kg package is raised from rest by an elevator at a constant acceleration of 2.00 m/s^2 for 20.0 s. (i) What is its KE at $t = 10.0$ s? (ii) What is its increase in gravitational potential energy after 10.0 s? (iii) Assuming no losses, how much work was done on it by the elevator in 10.0 s?
- (a) A rocket fires its engine, which exerts an average force of 1000 N for 40 s in a fixed direction. What is the magnitude of the rocket's momentum change?

(b) The glider on an air track has a mass of 1.00 kg and floats on compressed air, so it can move frictionlessly. Someone shoots a 20.0-g lump of clay at it. The clay strikes the glider, sticks to it, and both move away with a speed of 30 cm/s. What was the speed of the clay as it hit the glider?
- (a) A golf ball with a mass of 47.0 g can be blasted from rest to a speed of 100.0 m/s during the impact with a clubhead. Taking that impact to last only about 1.00 ms, (i) calculate the scalar value of the change in momentum of the ball. (ii) What is the average force on the ball during the collision?

(b) A rocket engine testing a low-power fuel expels 10.0 kg of exhaust gas per second. If these molecules are ejected at an average speed of 1.2 km/s, what is the thrust of the engine?
- An 8.0-m-long, 30-kg uniform plank leans against a smooth wall, making an angle of 60.0° with the ground. Compute the reaction force, \vec{F}_{RG} , of the ground on the plank.
- (a) A hollow cylinder, or hoop, of mass m rolls down an inclined plane from a height h . If it begins at rest, show that its final speed is given by $v = \sqrt{gh}$.

(b) A boy (mass 30 kg) wishes to play on a centrally pivoted seesaw with his dog Irving (mass 10 kg). When the dog sits 3.0 m from the pivot, where must the boy sit if the 6.5-m-long board is to be balanced horizontally?
- (a) An object of volume V floats in water with a volume V_u up above the surface. (i) Write an expression for its average density in terms of the density of water. (ii) Apply this solution to find the average density of a loaded barge with 20% of its volume above the waterline.

(b) A 227-kg block of cement, of density $2.8 \times 10^3 \text{ kg/m}^3$, rests on a pedestal in front of the Al Capone Memorial Library. How much did it weigh submerged while being hauled out of the river (freshwater)?
- (a) Using energy considerations, derive an expression for the period of oscillation of a mass m . It is fixed to a horizontal spring having an elastic constant k and is free to move on a frictionless table.

(b) The human thigh bone, the femur, at its narrowest point resembles a hollow cylinder with an outer radius of roughly 1.1 cm and an inner radius of just about half of that. Taking the compressive strength of the bone to be 170 MPa, how much force will be required to rupture it?