Mechanics Problem Set 2

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Problem 1. A ball with mass m is projected horizontally off the end of a table with an initial kinetic energy K. At a time after it leaves the end of the table it has kinetic energy $3K$. What is t? Neglect air resistance.

Problem 2. A 0.3 kg apple falls from rest through a height 40 cm onto a flat surface. Upon impact, the apple comes to rest in 0.1 s, and 4cm^2 of the apples comes in contact with the surface during this time. What is the average pressure exerted on the apple during the impact?

Problem 3. The total kinetic energy of a rolling body is the sum of its translational kinetic energy $\frac{1}{2}Mv^2$ and its rotational kinetic energy $\frac{1}{2}I\omega^2$. Suppose that a cylinder, a sphere, and a pipe (cylindrical shell) of equal masses 2 kg are rolling with equal speeds of 1 m/s. What is the total kinetic energy of each?

Problem 4. A block with mass m rests on a horizontal table. The coefficient of static friction between the block and the table is μ. You push down on the block with a force that is inclined at an angle θ from the table surface. What is the maximum force you can use without having the block move?

Problem 5. A mass of 3 kg sliding along a frictionless floor at 2 m/s strikes and compresses a spring of constant $k = 300$ N/m. The spring stops the mass. How far does the mass travel while being slowed by the spring? How long does the mass take to stop?

Problem 6. A spherical shell of mass M and radius R is completely filled with a frictionless fluid, also of mass M. It is released from rest, and then it rolls without slipping down an incline that makes an angle θ with the horizontal. What will be the acceleration of the shell down the incline just after it is released? Assume the acceleration of free fall is g.

Problem 7. The power output from a certain experimental car design to be shaped like a cube is proportional to the mass m of the car. The force of air friction on the car is proportional to Av^2, where v is the speed of the car and A the cross sectional area. On a level surface the car has a maximum speed v_{max}. Assuming that all versions of this design have the same density, then what is the value of α if $v_{max} \propto m^{\alpha}$?

Problem 8. Batman, who has a mass of $M = 100$ kg, climbs to the roof of a 30 m building and then lowers one end of a massless rope to his sidekick Robin. Batman then pulls Robin, who has a mass of $m = 75$ kg, up the roof of the building. Approximately how much total work has Batman done after Robin is on the roof?

Problem 9. A tension of 6000 Newtons is experienced by the elevator cable of an elevator moving upwards with an acceleration of $2.0 m/s^2$. What is the mass of the elevator?

Problem 10. Which is more likely to knock something over: being hit by a rubber bullet (that bounces off) or being hit by a metal bullet (that gets stuck) or being hit by a piercing bullet (that goes through)? All three bullets have the same mass and initial speed.