1. A 20 kg box is being pulled across a floor by a horizontal rope. The tension in the rope is 99 Newtons. The coefficient of friction is 0.25. What is the force of friction on the box? What is the acceleration of the box?

2. John is pushing (horizontally) on a 100 kg bench with a force of 380 Newtons. What is the size of the friction force acting on the bench if the coefficient of static friction is 0.4? Where will the bench be 10 seconds after John starts pushing?

3. A 38 kg crate rests on a floor. A horizontal pulling force of 170 N is needed to start the crate moving. What is the coefficient of static friction between the crate and the floor?

4. The same crate as in the previous question only requires a 120 N force to keep it moving at constant speed. What is the coefficient of sliding (kinetic) friction?

5. An 8 kg sled is being pulled across snow the snow, at constant speed, by a horizontal force of 15 Newtons. Find the coefficient of friction between the snow and sled.

6. A 56 kilogram cart is pulled along a horizontal road at constant speed of 2 m/s by a horizontal rope. The coefficient of friction between card and road is 0.69. Find the tension in the rope (the force the rope is applying).

7. A 2 kg book is held against a vertical wall. The coefficient of friction is 0.45. What is the minimum force that must be applied on the book, perpendicular to the wall, to prevent the book from slipping down the wall.

8. A 1200 kg car is travelling at 18 m/s when the brakes are applied and the wheels lock. The coefficient of friction between tires and road is 0.62. Draw a vector diagram showing all the forces at work. Find the acceleration of the car. Find the speed of the car after 1.2 seconds. Find the distance travelled, from when the brakes are first applied, for the car to come to a full stop.

9. A 50 N box is on a ramp that has a slant of 35 degrees. The ramp is perfectly slippery (coefficient of friction = 0). What is the acceleration of the box down the ramp?

10. A 200 N box is on a ramp that has a slant of 35 degrees. As above the ramp is frictionless. What is the acceleration of the box down the ramp?

11. A 50 N box is on a ramp that has a slant of 35 degrees. The coefficient of friction is 0.3. What is the acceleration of the box down the ramp?

12. A 5 kg mass is attached to the end of a 40 cm long horizontal spring (spring constant = 2500 N/m). The spring is stretched 10 cm, and then released. Suppose the mass is on a 25 kg table with coefficient of friction equal to 0.4. Draw a vector diagram of the forces at work and then determine the the initial acceleration of the mass when it is released?

13. The weight and spring of question 12 are hung vertically. At what final position will the weight hang?

Answers: (1) friction = 49 N, a = 2.5 m/s/s (2) 392 N, no movement (3) \( \mu = 0.4565 \) (4) \( \mu = 0.3222 \) (5) \( \mu = 0.1913 \) (6) 378.67 N (7) 43.55 N (8) -6.076 m/s/s, 10.7 m/s, 26.66 m (9) 5.62 m/s/s (10) 5.62 m/s/s (11) 3.21 m/s/s (12) 46.08 m/s/s (13) 0.0196 m