Seminar 2

Newton's Laws, Work, Momentum and Impulse

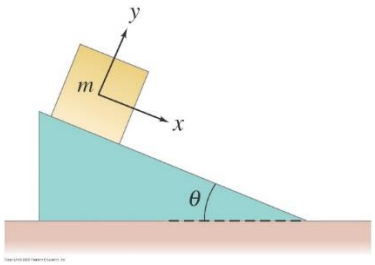
Using Newton's Law:

1. How much tension must a rope withstand if it is used to accelerate a 1210 kg car horizontally along a frictionless surface at 1.20 ms^{-2}?

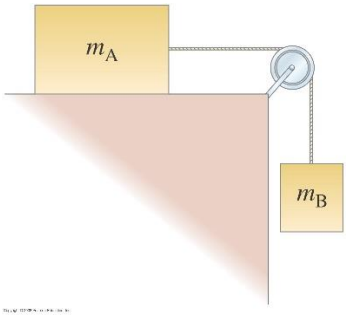
2. (a) What is the acceleration of two falling sky divers (mass = 132 kg including parachute) when the upward force of air resistance is equal to one-fourth of their weight? (b) After popping open the parachute, the divers descend leisurely to the ground at constant speed. What now is the force of air resistance on the sky divers and their parachute? See the figure below.

3. The block shown in the figure below has a mass m = 7.0 kg and lies on a fixed smooth frictionless plane tilted at an angle θ = 22.0° to the horizontal.

   (a) Determine the acceleration of the block as it slides down the plane. (b) If the block starts from rest 12.0 m up the plane from its base, what will be the block's speed when it reaches the bottom of the incline?

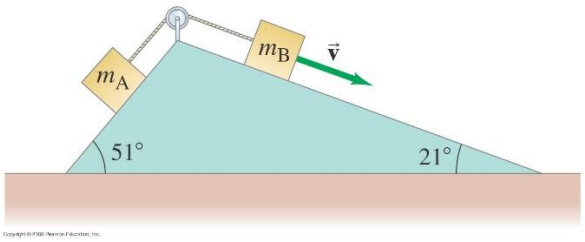


4. (*a*) If m_A = 13.0 kg and m_B = 5.0 kg in the figure below, determine the acceleration of each block. (b) If initially m_A is at rest 1.250 m from the edge of the table, how long does it take to reach the edge of the table if the system is allowed to move freely? (c) If m_B = 1.0 kg, how large must m_A be if the acceleration of the system is to be kept at $\frac{1}{100}$g?



Friction and Newton's Laws:

5. Two masses m_A = 2.0 kg and m_B = 5.0 kg are on inclines and are connected together by a string as shown in the figure below. The coefficient of kinetic friction between each mass and its incline is μ_k = 0.30. If m_A moves up, and m_B moves down, determine their acceleration.

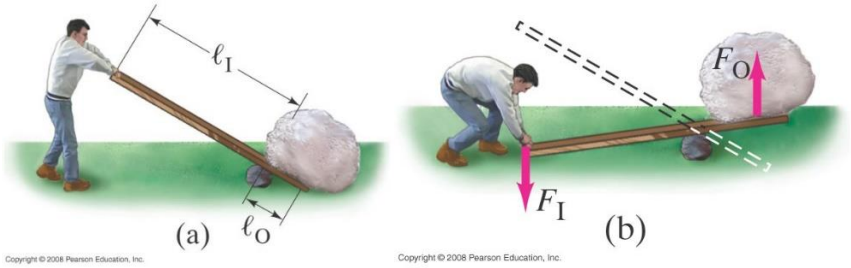


Work Done by a Constant Force:

6. How high will a 1.85 kg rock go if thrown straight up by someone who does 80.0 J of work on it? Neglect air resistance.

7. A lever such as that shown in the figure below can be used to lift objects we might not otherwise be able to lift. Show that the ratio of the output force, F_0, to input force, F_I, is related to the lengths l_I and l_0 from the pivot by $\frac{F_0}{F_I} = \frac{l_I}{l_0}$.

   Ignore friction and the mass of the lever, and assume the work output equals work input.



Work Done by a Varying Force:

8. In pedaling a bicycle uphill, a cyclist exerts a downward force of 450 N during each stroke. If the diameter of the circle traced by each pedal is 36 cm, calculate how much work is done in each stroke.

The Work-Energy Principle:

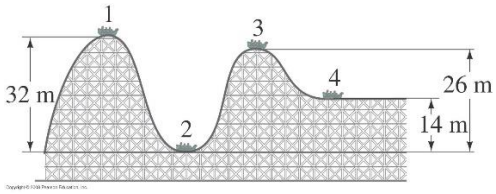
9. How much work is required to stop an electron (m = 9.11 X 10^{-31} kg) which is moving with a speed of 1.40 $\times$ 10^6 ms^{-1}?

Conservative Forces and Potential Energy:

10. A 1200 kg car rolling on a horizontal surface has speed v = 75 kmh^{-1} when it strikes a horizontal coiled spring and is brought to rest in a distance of 2.2 m. What is the spring stiffness constant of the spring?

Conservation of Mechanical Energy:

11. A roller-coaster car shown in the figure below is pulled up to point 1 where it is released from rest. Assuming no friction, calculate the speed at points 2, 3 and 4.



Momentum:

12. Air in a 120 kmh^{-1} wind strikes head-on the face of a building 45 m wide by 65 m high and is brought to rest. If air has a mass of 1.3 kg per cubic metre, determine the average force of the wind on the building.

Conservation of Momentum:

13. A 9150 kg railroad car travels alone on a level frictionless track with a constant speed of 15.0 ms^{-1}. A 4350 kg load, initially at rest, is dropped onto the railroad car. What will be the car's new speed?

14. A 22 g bullet traveling 210 ms^{-1} penetrates a 2.0 kg block of wood and emerges going 150 ms^{-1}. If the block is stationary on a frictionless surface when hit, how fast does it move after the bullet emerges?

Collisions and Impulse:

15. A 12 kg hammer strikes a nail at a velocity of 8.5 ms^{-1} and comes to rest in a time interval of 8.0 ms. (a) What is the impulse given to the nail? (*b*) What is the average force acting on the nail?

16. Suppose the force acting on a tennis ball (mass 0.060 kg) points in the +*x* direction and is given by the graph of the figure below as a function of time. Use graphical methods to estimate (*a*) the total impulse given to the ball, and (*b*) the velocity of the ball after being struck, assuming the ball is being served so it is nearly at rest initially.