

1. Compare the kinetic energy of a 20,000-kg truck moving at 110 km/h with that of an 80.0-kg astronaut in orbit moving at 27,500 km/h.

$$KE_1 = \frac{1}{2}mv^2 = (20,000) \left(\frac{110 \text{ km/h}}{3600} \right) \left(\frac{1000 \text{ m}}{1 \text{ km}} \right) \left(\frac{1 \text{ h}}{3600 \text{ s}} \right) = 9.34 \times 10^6 \text{ J}$$

$$KE_2 = \frac{1}{2} (80) (27,500 \frac{\text{km}}{\text{h}}) \left(\frac{1000 \text{ m}}{1 \text{ km}} \right) \left(\frac{1 \text{ h}}{3600 \text{ s}} \right) = 2.334 \times 10^9 \text{ J}$$

$$\frac{KE_{\text{truck}}}{KE_{\text{astr}}} = \frac{9.34 \times 10^6 \text{ J}}{2.334 \times 10^9 \text{ J}} = \frac{1}{249.29} \rightarrow KE_{\text{truck}} = \left(\frac{1}{249} \right) KE_{\text{astr}}$$

2. A pitcher throws a 143 gram baseball toward the catcher at 45 m/s. If the catcher's hand moves back a distance of 6cm in stopping the ball determine the average force exerted on the catcher's hand.

$$W = \Delta KE = KE_1 - KE_2 = \frac{1}{2} (0.143) (45)^2 - 0 = 1447.8 \text{ J}$$

$$W = Fd \rightarrow F = \frac{W}{d} = \frac{1447.8 \text{ J}}{0.06} = 24,131.2$$

3. (a) How fast must a 3000-kg elephant move to have the same kinetic energy as a 65.0-kg sprinter running at 10.0 m/s? (b) Discuss how the larger energies needed for the movement of larger animals would relate to metabolic rates.

$$KE_s = \frac{1}{2}mv^2 = \frac{1}{2} (65) (10)^2 = 3250 \text{ J}$$

$$v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2(3250)}{3000}} = 1.47$$

$$v^2 = v_0^2 + 2ad$$

$$0 = (25)^2 + 2a(120)$$

$$d = 2.6 \rightarrow F_{\text{max}} = 950.266$$

$$90 \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ h}}{3600 \text{ s}} = 25$$

4. 12. (a) Calculate the force needed to bring a 950-kg car to rest from a speed of 90.0 km/h in a distance of 120 m (a fairly typical distance for a non-panic stop). (b) Suppose instead the car hits a concrete abutment at full speed and is brought to a stop in 2.00 m. Calculate the force exerted on the car and compare it with the force found in part (a).

$$W = KE_f - KE_0 = \frac{1}{2} (950) (25)^2 - 0 = 296,875$$

$$F = \frac{W}{d} = \frac{296,875}{120} = 2473.95$$

$$F = \frac{W}{d} = \frac{296,875}{2} = 148,437.5$$

$$\frac{F_0}{F_1} = \frac{148,437.5}{2473.95} = 60 \times \text{over}$$

5. A car's bumper is designed to withstand a 4.0-km/h (1.12-m/s) collision with an immovable object without damage to the body of the car. The bumper cushions the shock by absorbing the force over a distance. Calculate the magnitude of the average force on a bumper that collapses 0.200 m while bringing a 900-kg car to rest from an initial speed of 1.12 m/s.

$$W = \Delta KE = \frac{1}{2}mv^2 - 0$$

$$= \frac{1}{2}(900)(1.12)^2 = 564.48$$

$$F = \frac{W}{d} = \frac{564.48}{0.02} = 28,224 \text{ N}$$

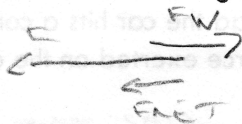
6. Boxing gloves are padded to lessen the force of a blow. (a) Calculate the force exerted by a boxing glove on an opponent's face, if the glove and face compress 7.50 cm during a blow in which the 7.00-kg arm and glove are brought to rest from an initial speed of 10.0 m/s. (b) Calculate the force exerted by an identical blow in the gory old days when no gloves were used and the knuckles and face would compress only 2.00 cm. (c) Discuss the magnitude of the force with glove on. Does it seem high enough to cause damage even though it is lower than the force with no glove?

$$W = \Delta KE = \frac{1}{2}(7 \text{ kg})(10 \text{ m/s})^2 - 0 = 350$$

$$F = \frac{350}{0.075} \times \frac{100 \text{ cm}}{1 \text{ m}} = 4,666.67 \text{ N}$$

$$2) F = \frac{350}{0.02} \times \frac{100 \text{ cm}}{1 \text{ m}} = 1750 \text{ N}$$

7. Using energy considerations, calculate the average force a 60.0-kg sprinter exerts backward on the track to accelerate from 2.00 to 8.00 m/s in a distance of 25.0 m, if he encounters a headwind that exerts an average force of 30.0 N against him.



$$F_{\text{NET}} = F - F_W$$

$$W = F_{\text{NET}} d$$

$$W = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2 = \frac{1}{2}(60)(8)^2 - \frac{1}{2}(60)(2)^2$$

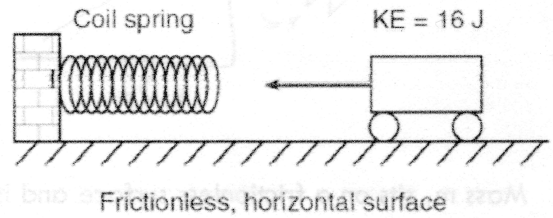
$$= 1920 - 120 = 1800$$

$$F_{\text{NET}} = \frac{1800}{25} = 72 \text{ N}$$

$$F = F_{\text{NET}} + F_W = 72 \text{ N} + 30 \text{ N} = 102 \text{ N}$$

CALCULATE BY

1. The diagram below shows a toy cart possessing 16 joules of kinetic energy traveling on a frictionless, horizontal surface toward a horizontal spring. If the cart comes to rest after compressing the spring a distance of 1.0 meter, what is the spring constant of the spring?
 (a) 32 N/m (b) 16 N/m (c) 8.0 N/m (d) 4.0 N/m



$$KE = PE = \frac{1}{2} kx^2$$

$$k = \frac{2KE}{x^2} = \frac{2(16)}{(1)^2} = 32$$

2. A child does 0.20 J of work to compress the spring in a pop-up toy. If the mass of the toy is 0.010 kg, what is the maximum vertical height that the toy can reach after the spring is released? (a) 20 m (b) 2.0 m (c) 0.20 m (d) 0.020 m

$$PE_{\text{spring}} = KE_{\text{toy}}$$

$$mg\Delta y = \frac{1}{2}mv^2$$

$$v = \sqrt{2g\Delta y}$$

3. A lawyer knocks her folder of mass m off her desk of height Δy . What is the speed of the folder upon striking the floor?
 A) square root of $2g\Delta y$ B) $2g\Delta y$ C) $mg\Delta y$ D) $m\Delta y$

$$PE_s = PE_g = mg\Delta y$$

$$\Delta h = \frac{PE_g}{mg} = \frac{0.20}{(0.01)(9.8)} = 2m$$

4. A 65kg pole vaulter wishes to vault to a height of 5.5 meters. A) Calculate minimum amount of Kinetic Energy the vaulter needs to reach this height if air resistance is neglected, and all the vaulting energy is derived from kinetic energy. B) Calculate speed vaulter must attain to have necessary kinetic energy.

$$KE = PE_g = mg\Delta h$$

$$KE = (65 \text{ kg})(5.5)(9.8) = 3500 \text{ J}$$

$$KE = \frac{1}{2}mv^2 \rightarrow v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2(3500)}{65 \text{ kg}}} = 10$$

5. A pendulum of mass M swings on a light string of length L as shown. If the mass is released from rest at an angle of θ , find the maximum speed of the pendulum as a function of θ , L any other required constants.

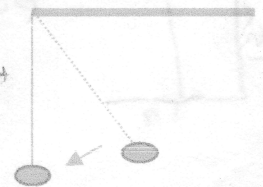
FIND PE_g AT HIGHEST POINT $PE_g = mgh \rightarrow h = L(1 - \cos\theta)$

$$PE_g = mgL\cos\theta$$

PE_g CONVERTED TO KE AT LOWEST POINT SOLVE FOR v AT LOWEST

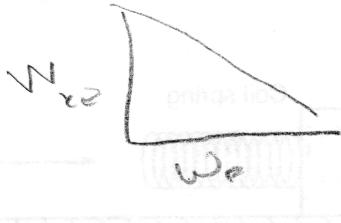
$$PE_g = KE \rightarrow mgL(1 - \cos\theta) = \frac{1}{2}mv^2$$

$$v = \sqrt{2gL(1 - \cos\theta)}$$



6. The work done in accelerating an object along a frictionless horizontal surface is equal to the change in the object's: A) Momentum B) Velocity C) Potential Energy D) Kinetic Energy

6. A car, initially traveling at 30m/s, slows uniformly as it skids to a stop after the brakes are applied. Sketch a graph showing the relationship between the kinetic energy of the car and the work done by friction in stopping the car.



7. Mass m_1 sits on a frictionless surface and is attached by a light string across a frictionless pulley to mass m_2 as shown. What happens to the gravitational potential energy and kinetic energy of m_1 and m_2 when m_2 is released from rest?

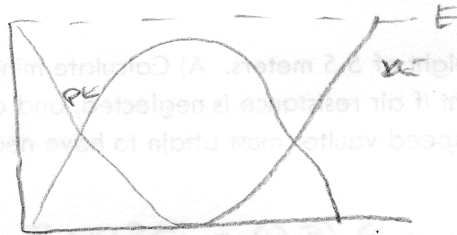
PE of m_1 - same KE, \uparrow
 PE of m_2 \downarrow KE of m_2 \uparrow



8. A box of mass m is attached to a spring (spring constant k) and sits on a frictionless horizontal surface. The spring is compressed a distance x from its equilibrium position and released. Determine the speed of the box when the spring returns to its equilibrium position.

$$PE_s = KE \rightarrow \frac{1}{2}kx^2 = \frac{1}{2}mv^2 \rightarrow v = \sqrt{\frac{k}{m}}x$$

9. A ball is thrown vertically upwards. Plot the ball's total mechanical energy, kinetic energy and gravitational potential energy.



10. Andy the adventurous while running from evil bad guys in the Amazonian rainforest, trips, falls and slides down a frictionless mudslide of height 20 meters. Once he reaches the bottom of the mudslide, he has the misfortune to fly horizontally off a 1.5-m cliff. How far from the base of the cliff does Andy land?

MUDSLIDE - $PE_g = mgh = \frac{1}{2}mv^2$
 $v = \sqrt{2gh} = \sqrt{2(9.8)(20)} = 19.6 \text{ m/s}$

PROSEAUCE - FIRE \downarrow
 $\Delta y = v_{y0}t + \frac{1}{2}a_y t^2 \rightarrow t = \sqrt{\frac{2\Delta y}{a_y}} = \sqrt{\frac{2(1.5)}{9.8}} = 1.75 \text{ s}$
 $\Delta x = v_{x0}t = (19.6)(1.75) = 34.3 \text{ m}$