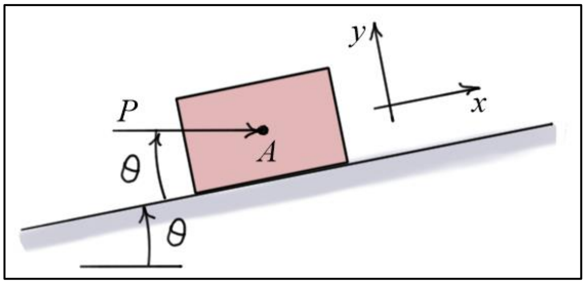
Elementary Dynamics
Exercises #4 – Newton's Laws for Particle Motion

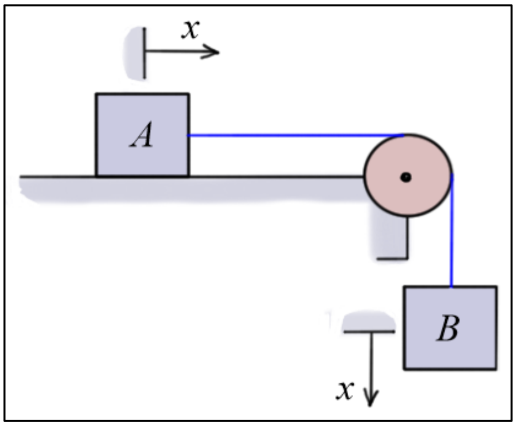
1. Block A is ***released*** from ***rest*** on the inclined plane. The mass of A is $m = 10\ (\text{kg})$, the angle $\theta = 30\ (\text{deg})$, and the horizontal force $P = 45\ (\text{N})$. Assuming the ***friction*** between A and the plane is ***negligible***, find: a) N the normal force between A and the plane, b) a the acceleration of A, and c) $v(t = 2)$ the velocity of A two seconds after release.



Answers:

a) $N \approx 107\ (\text{N})$; b) $\underset{\sim}{a} \approx -1.01\underset{\sim}{e}_x\ (\text{m/s}^2)$; c) $\underset{\sim}{v}(t = 2) \approx -2.02\underset{\sim}{e}_x\ (\text{m/s})$ … motion down the plane

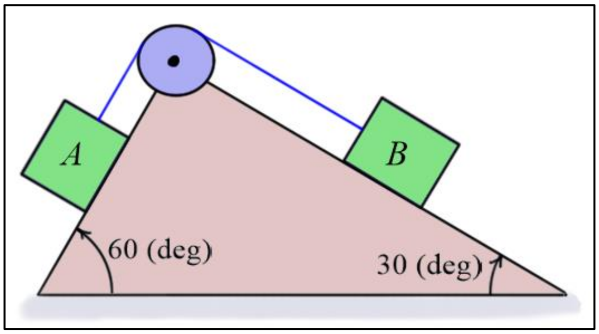
2. The system shown consists of two blocks A and B connected by a ***light cable***. Block A weighs $W_A = 100\ (\text{lb})$. The static and kinetic coefficients of friction between A and the plane are $\mu_S = 0.25$ and $\mu_K = 0.15$. Find: a) $(W_B)_{\min}$ the minimum weight of B required to start the system moving, and b) a the acceleration of the masses and T the tension in the cable given $W_B = 50\ (\text{lb})$.



Answers:

a) $(W_B)_{\min} = 25\ (\text{lb})$; b) $a \approx 7.51\ (\text{ft/s}^2)$ and $T \approx 38.3\ (\text{lb})$

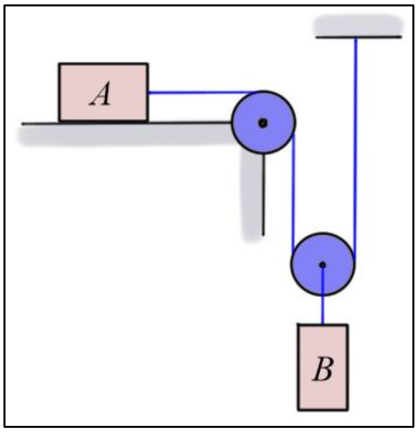
3. The two blocks A and B are connected by a ***light*** cable and slide on the inclined planes. If each of the blocks weighs $W = 10\ (\text{lb})$ and the coefficient of kinetic friction between the blocks and the planes is $\mu_k = 0.1$, find a) a the acceleration of the blocks, and b) T the tension in the cable.



Answers:

a) $a \approx 3.69\ (\text{ft/s}^2)$; b) $T \approx 7.01\ (\text{lb})$

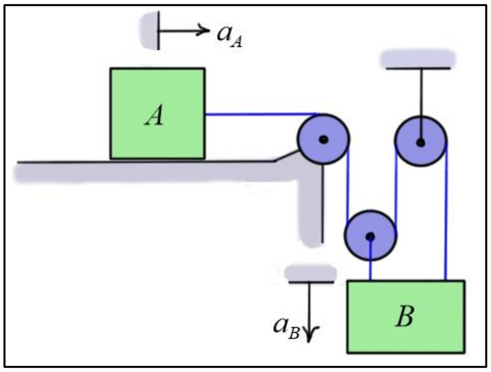
4. The two blocks *A* and *B* are connected by a ***light*** cable and pulley system. The weights of the blocks are $W_A = 50$ (lb) and $W_B = 100$ (lb), and the coefficient of kinetic friction between *A* and the plane is $\mu_K = 0.3$. The system is ***released*** from ***rest***, and *B* ***moves down***. Find: a) the relationship between the accelerations of *A* and *B*, b) a_A the ***acceleration*** of block *A*, and c) *T* the ***tension*** in the cable.



Answers:

a) $a_A = 2a_B$; b) $a_A \approx 15.0$ (ft/s^2); c) $T \approx 38.3$ (lb)

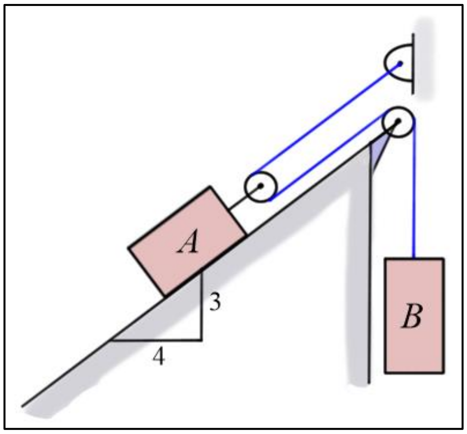
5. The system shown has two blocks *A* and *B* connected by a ***light*** cable and pulley system. The ***weight*** of *A* is $W_A = 20$ (lb), the ***weight*** of *B* is $W_B = 30$ (lb), and the static and kinetic coefficients of friction are $\mu_s = 0.4$ and $\mu_k = 0.3$. At the instant the system is ***released*** from ***rest***, find: a) the relationship between the accelerations of *A* and *B*, b) *T* the tension in the cable, and c) a_A and a_B the accelerations of *A* and *B*.



Answers:

a) $a_A = 3a_B$; b) $T \approx 9.43$ (lb); c) $a_A \approx 5.52$ (ft/s^2) and $a_B \approx 1.84$ (ft/s^2)

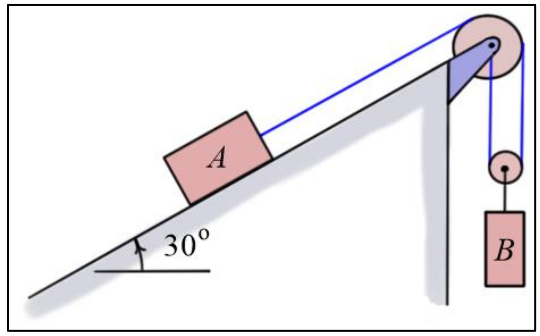
6. The two blocks *A* and *B* are connected by a ***light*** cable and pulley system. The weights of the blocks are $W_A = 60$ (lb) and $W_B = 10$ (lb), and the coefficient of kinetic friction is $\mu_k = 0.2$. When the system is ***released*** from ***rest***, block *A* moves ***down the plane*** and block *B* ***moves up***. Find: a) the relationship between the accelerations of *A* and *B*, and b) a_A the ***acceleration*** of block *A* and *T* the ***tension*** in the cable.



Answers:

a) $a_B = 2a_A$; b) $a_A \approx 2.06$ (ft/s^2), $T \approx 11.3$ (lb)

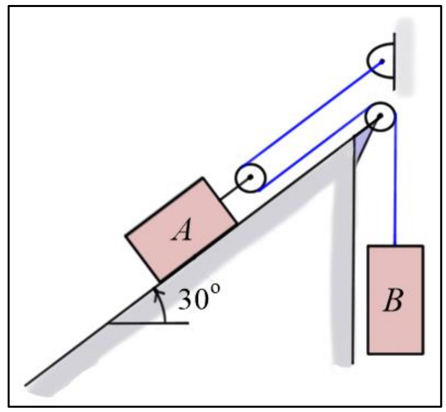
7. The two blocks *A* and *B* are connected by a ***light*** cable and pulley system. The masses of the blocks are $m_A = 60$ (kg) and $m_B = 20$ (kg), and the coefficient of kinetic friction is $\mu_k = 0.2$. When the system is ***released*** from ***rest***, *A* moves ***down the plane*** and *B* ***moves up***. Find: a) the relationship between the accelerations of *A* and *B*, and b) a_B the ***acceleration*** of block *B* and *T* the ***tension*** in the cable.



Answers:

a) $a_A = 2a_B$; b) $a_B \approx 0.725$ (m/s^2) ; $T \approx 105$ (N)

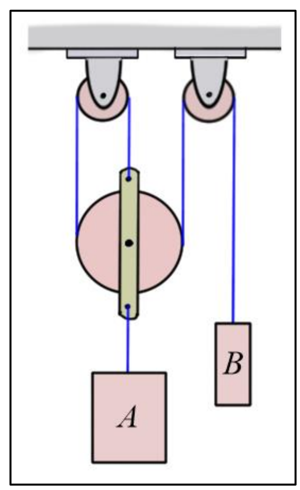
8. The system shown consists of two blocks *A* and *B* connected by a ***light*** cable and pulley system. The weights of the blocks are $W_A = 50$ (lb) and $W_B = 100$ (lb), and the coefficient of kinetic friction between the block and the plane is $\mu_K = 0.3$. When the system is ***released*** from ***rest***, *B* ***moves down***. Find: a) the relationship between the accelerations of *A* and *B*, b) a_A the ***acceleration*** of block *A*, and c) *T* the ***tension*** in the cable.



Answers:

a) $a_A = \frac{1}{2}a_B$; b) $a_A \approx 11.6$ (ft/s^2); c) $T \approx 28$ (lb)

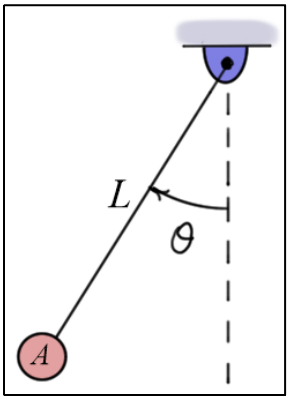
9. The two blocks *A* and *B* are connected by a ***light*** cable and pulley system. The masses of the blocks are $m_A = 100$ (kg) and $m_B = 25$ (kg). The system is ***released*** from ***rest***, and *A* ***moves down***. Find: a) the relationship between the accelerations of blocks *A* and *B*, and b) a_A the ***acceleration*** of block *A*, and c) *T* the ***tension*** in the cable.



Answers:

a) $a_B = 3a_A$; b) $a_A \approx 0.755$ (m/s^2); c) $T \approx 302$ (N)

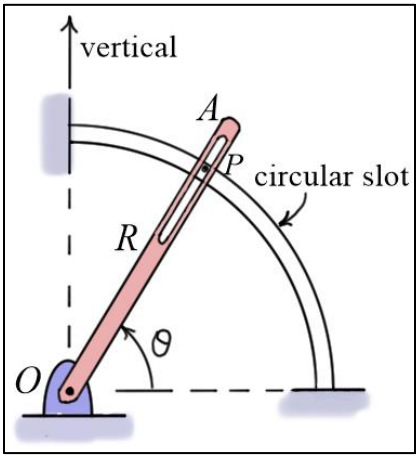
10. The figure shows a ***simple pendulum*** which consists of a ball *A* on the end of a ***light*** cable. The weight of *A* is $W_A = 10\ (\text{lb})$, and the length of the cable is $L = 5\ (\text{ft})$. When angle $\theta = 30\ (\text{deg})$, *A* is observed to be ***swinging downward***, and the ***tension*** in the cable is measured to be $T = 15\ (\text{lb})$. At this instant, find: a) $\dot{v} = dv/dt$ the rate of change of the speed of *A*, and b) v the speed of *A*.



Answers:

a) $\dot{v} \approx 16.1\ (\text{ft/s}^2)$; b) $v \approx 10.1\ (\text{ft/s})$

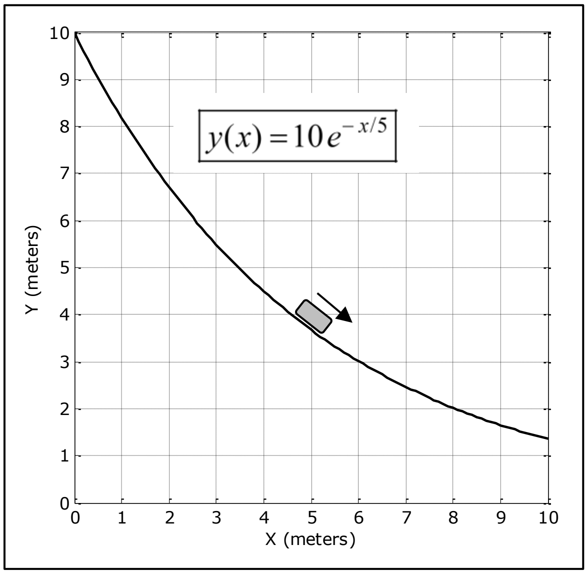
11. The system shown consists of a ***fixed circular slot*** of radius $R = 0.5\ (\text{m})$ and a ***rotating bar*** *OA* in a ***vertical plane***. Pin *P* has mass $m = 2\ (\text{kg})$ and is moved along the circular slot by the motion of *OA*. *P* is slightly smaller than both slots, so it is free to rest against two of the four surfaces of the slots. ***Friction*** between the pin and the slots is ***negligible***. When the bar is at an angle $\theta = 60\ (\text{deg})$, the time derivatives of θ are known to be $\dot{\theta} = d\theta/dt = 5\ (\text{rad/sec})$ and $\ddot{\theta} = d^2\theta/dt^2 = -20\ (\text{rad/sec}^2)$. At this instant, find: a) N the force that the circular slot exerts on *P*, and b) F the force that arm *OA* exerts on *P*.



Answers:

a) $\underset{\sim}{N} \approx -8\underset{\sim}{e}_r\ (\text{N})$; b) $\underset{\sim}{F} \approx -10.2\underset{\sim}{e}_\theta\ (\text{N})$

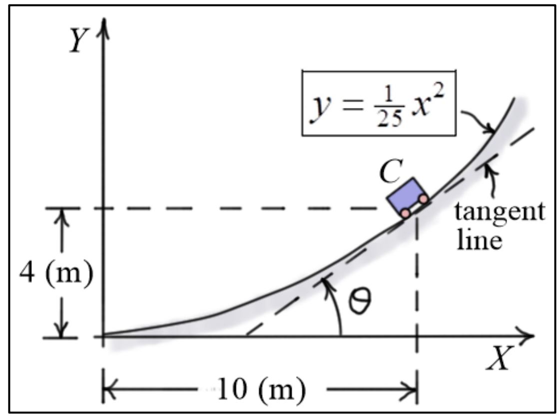
12. A ***sled*** is traveling ***down*** a hill which can be approximated by the function $y(x) = 10e^{-x/5}$. The ***mass*** of the sled (and passenger) is $m = 80\ (\text{kg})$, and the coefficient of kinetic friction is $\mu_k = 0.1$. At the location shown, $x = 5\ (\text{m})$ and the ***speed*** of the sled is $v = 10\ (\text{m/s})$. At this time, find: a) N the normal force exerted on the sled by the hill, and b) $\dot{v}$ the ***time rate of change of the speed*** of the sled.



Answers:

a) $\underset{\sim}{N} \approx 1.25\underset{\sim}{e}_n\ (\text{kN})$; b) $\dot{v} \approx 4.25\ (\text{m/s}^2)$

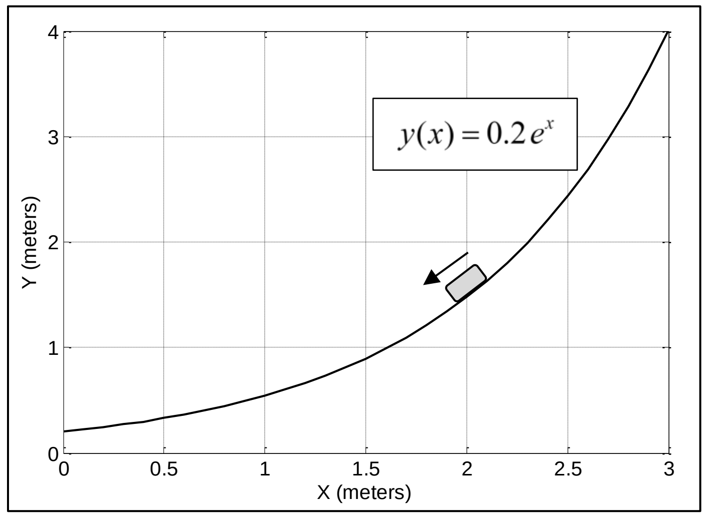
13. The 100 (kg) cart C is travelling up a vertical, parabolic ramp. The kinetic coefficient of friction between the cart and the ramp is $\mu_k = 0.3$. At the instant shown, the velocity of the cart is $v_C = 5 \text{ (m/s)}$. At this instant, find: a) ρ the radius of curvature, b) N_C the normal force the path exerts on C, and c) $\dot{v}$ the rate of change of the speed of C.



Answers:

a) $\rho \approx 26.25 \text{ (m)}$; b) $N_C \approx 861 \text{ (N)}$; c) $\dot{v} \approx 8.71 \text{ (m/s}^2\text{)}$

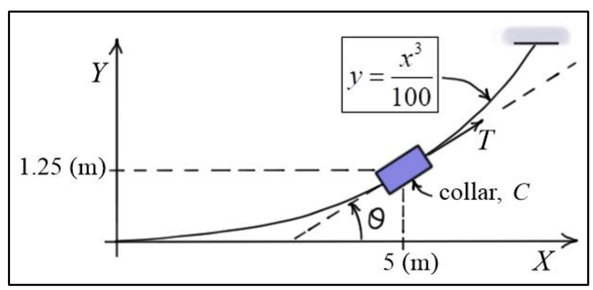
14. An 8 (kg) sack is sliding down a smooth ramp which can be approximated by the function $y(x) = 0.2\, e^x$. At the location shown, $x = 2 \text{ (m)}$ and the ***speed*** of the sack is $v = 5 \text{ (m/s)}$. At this location, find: a) θ the angle between the vertical (Y axis) and the normal to the curve, b) ρ the radius of curvature, c) N the normal force exerted on the sack by the ramp, and d) $\dot{v}$ the time rate of change of the speed of the sack.



Answers:

a) $\theta \approx 55.9 \text{ (deg)}$; b) $\rho \approx 3.84 \text{ (m)}$; c) $N \approx 96.0 \text{ (N)}$; d) $\dot{v} \approx 8.12 \text{ (m/s}^2\text{)}$

15. The 100 (kg) collar C is driven along a wire path in the ***vertical*** plane by the thrust force T. T is always ***tangent*** to the path, and the kinetic coefficient of friction between the collar and the wire path is $\mu_k = 0.3$. At the instant shown, the speed of the collar is $v_C = 5 \text{ (m/s)}$ and is ***increasing*** at a rate $\dot{v}_C = 20 \text{ (m/s}^2\text{)}$. At this instant, find:

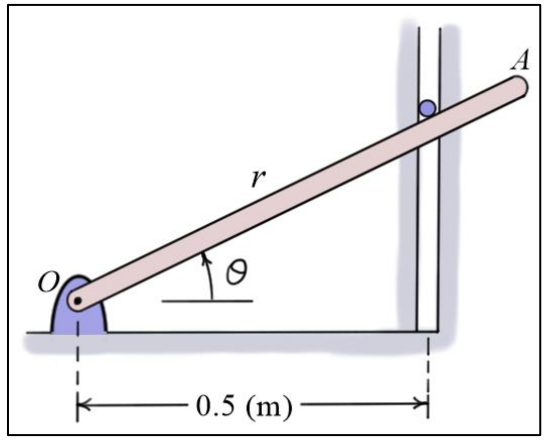


a) θ the angle between the X axis and the tangent line, b) ρ the radius of curvature, c) N the ***normal force*** the path exerts on the collar, and d) T the ***thrust force*** acting on the collar.

Answers:

a) $\theta \approx 36.9 \text{ (deg)}$; b) $\rho \approx 6.51 \text{ (m)}$; c) $N \approx 1170 \text{ (N)}$, d) $T \approx 2940 \text{ (N)}$

16. The small ball has mass $m = 0.5$ (kg), and it is confined to move along the ***smooth vertical slot*** due to the rotation of arm *OA*. The arm is rotating at a ***constant rate*** of $\dot{\theta} = 2$ (rad/s). At $\theta = 30$ (deg) find a) a_r and a_θ the ***radial*** and ***transverse*** components of the ***acceleration*** of the ball, and b) F_{OA} and F_S the ***forces*** the ***arm*** *OA* and the vertical ***slot*** exert on the ball. Assume the ball contacts only one side of the slot at any time and that all surfaces are ***smooth***.



Answers:

a) $\underset{\sim}{a} = 1.54\,\underset{\sim}{e}_r + 2.67\,\underset{\sim}{e}_\theta$ (m/s^2), b) $\underset{\sim}{F}_{OA} = 7.44\,\underset{\sim}{e}_\theta$ (N), $\underset{\sim}{F}_S = 3.72\,\underset{\sim}{i}$ (N)