**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 $m = 10$ (kg), the angle $\theta = 30$ (deg), and the horizontal force $P = 45$ (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.
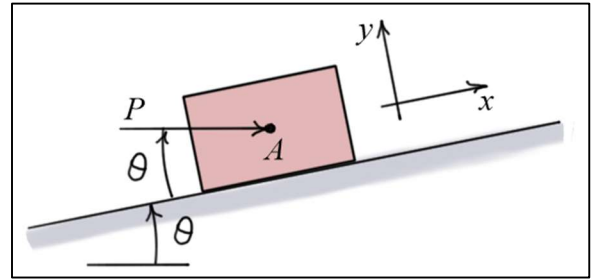
   Answers:

   a) $N \approx 107$ (N); b) $\underset{\sim}{a} \approx -1.01\underset{\sim}{e}_x$ (m/s^2); c) $\underset{\sim}{v}(t = 2) \approx -2.02\underset{\sim}{e}_x$ (m/s) … motion down the plane
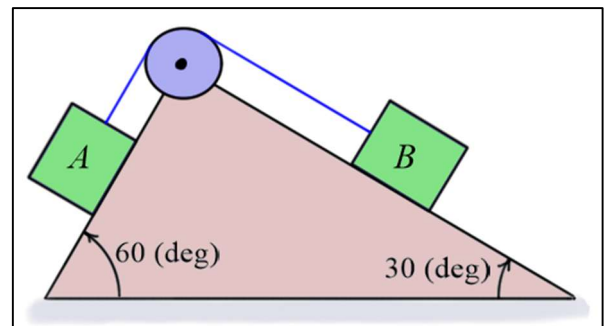
2. The system shown consists of two blocks A and B connected by a **light cable**. Block A weighs $W_A = 100$ (lb). The static and kinetic coefficients of friction between A and the plane are $\mu_S = 0.25$ and $\mu_K = 0.15$. Find: a) $(W_B)_{\min}$ the minimum weight of B required to start the system moving, and b) a the acceleration of the masses and T the tension in the cable given $W_B = 50$ (lb).
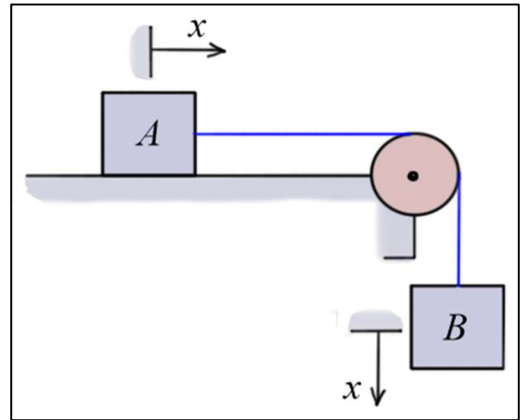
   Answers:

   a) $(W_B)_{\min} = 25$ (lb); b) $a \approx 7.51$ (ft/s^2) and $T \approx 38.3$ (lb)
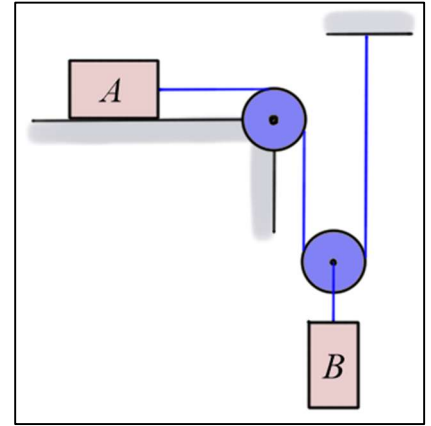
3. The two blocks A and B are connected by a **light** cable and slide on the inclined planes. If each of the blocks weighs $W = 10$ (lb) and the coefficient of kinetic friction between the blocks and the planes is $\mu_k = 0.1$, find a) a the acceleration of the blocks, and b) T the tension in the cable. Answers:

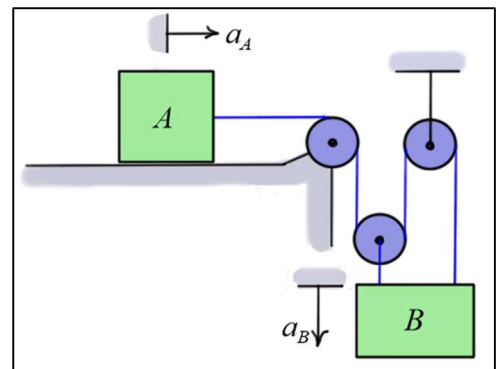   a) $a \approx 3.69$ (ft/s^2); b) $T \approx 7.01$ (lb)

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) $a_A = 2 a_B$; 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) $a_A = 3 a_B$; b) $T \approx 9.43$ (lb); c) $a_A \approx 5.52$ (ft/s^2) and $a_B \approx 1.84$ (ft/s^2)
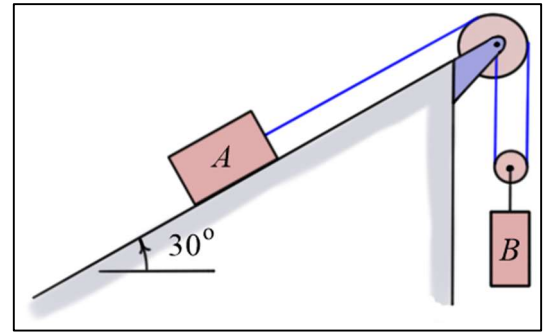
6. The two blocks A and B are connected by a *light* cable and pulley system. The weights of the blocks are $W_A = 60$ (lb) and $W_B = 10$ (lb), and the coefficient of kinetic friction is $\mu_k = 0.2$. When the system is *released* from *rest*, block A moves *down the plane* and block B *moves up*. 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.
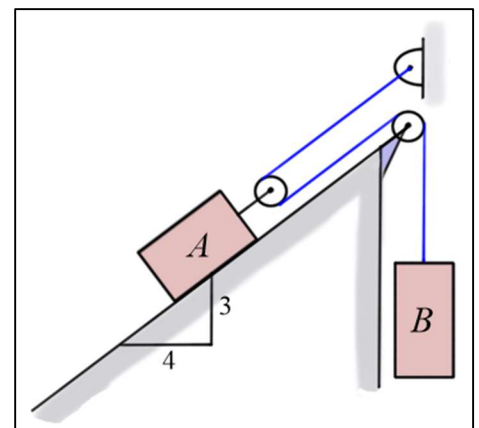
   Answers:

   a) $a_B = 2 a_A$; b) $a_A \approx 2.06$ (ft/s^2), $T \approx 11.3$ (lb)
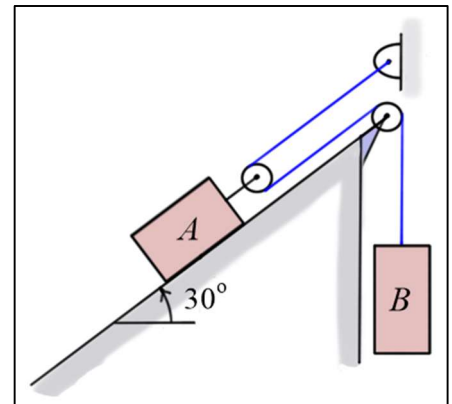
7. The two blocks A and B are connected by a **light** cable and pulley system. The masses of the blocks are $m_A = 60$ (kg) and $m_B = 20$ (kg), and the coefficient of kinetic friction is $\mu_k = 0.2$. When the system is **released** from **rest**, A moves **down the plane** and B **moves up**. Find: 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.
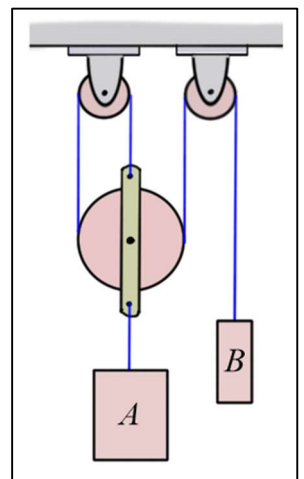
    Answers:

    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 $W_A = 10$ (lb), and the length of the cable is $L = 5$ (ft). When angle $\theta = 30$ (deg), A is observed to be **swinging downward**, and the **tension** in the cable is measured to be $T = 15$ (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.
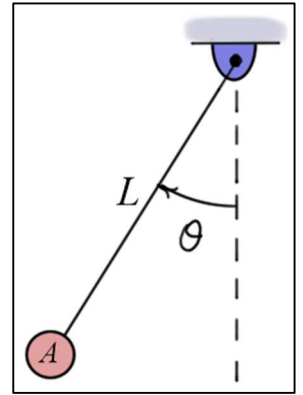
Answers:

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

11. The system shown consists of a **fixed circular slot** of radius $R = 0.5$ (m) and a **rotating bar OA** in a **vertical plane**. Pin P has mass $m = 2$ (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 $\theta = 60$ (deg), the time derivatives of θ are known to be $\dot{\theta} = d\theta/dt = 5$ (rad/sec) and $\ddot{\theta} = d^2\theta/dt^2 = -20$ (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.
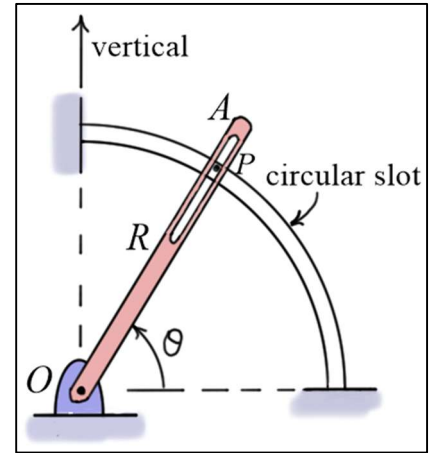
Answers:

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

12. A **sled** is traveling **down** a hill which can be approximated by the function $y(x) = 10\,e^{-x/5}$. The **mass** of the sled (and passenger) is $m = 80$ (kg), and the coefficient of kinetic friction is $\mu_k = 0.1$. At the location shown, $x = 5$ (m) and the **speed** of the sled is $v = 10$ (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.
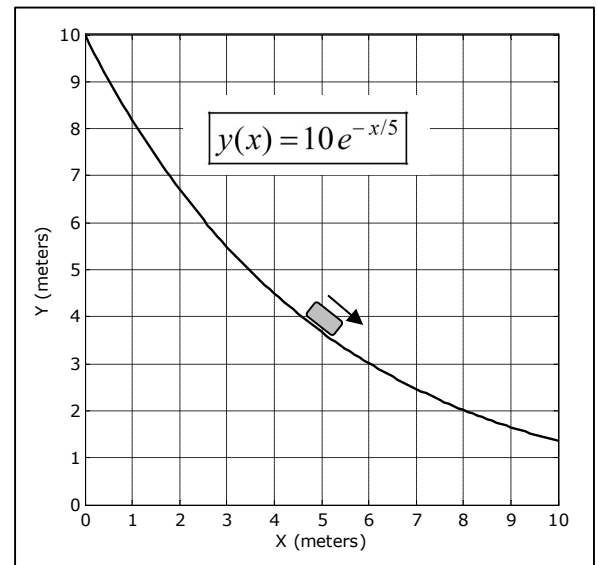
Answers:

   a) $\underset{\sim}{N} \approx 1.25\,\underset{\sim}{e}_n$ (kN); b) $\dot{v} \approx 4.25$ (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 $v_C = 5$ (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) $\rho \approx 26.25$ (m); b) $N_C \approx 861$ (N); c) $\dot{v} \approx 8.71$ (m/s^2)
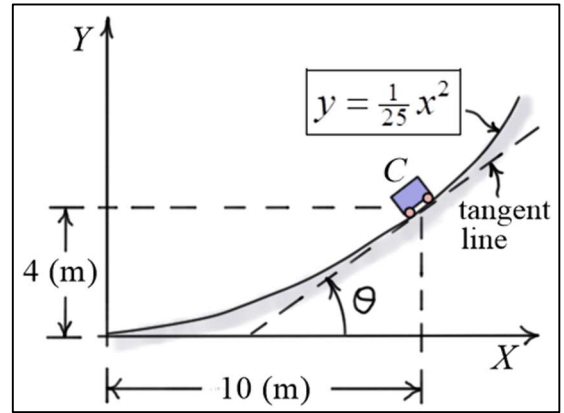
14. An 8 (kg) sack is sliding down a smooth ramp which can be approximated by the function $y(x) = 0.2e^x$. At the location shown, $x = 2$ (m) and the **speed** of the sack is $v = 5$ (m/s). At this location, find: a) θ the angle between the vertical (Y axis) and the normal to the curve, b) ρ the radius 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) $\theta \approx 55.9$ (deg); b) $\rho \approx 3.84$ (m); c) $N \approx 96.0$ (N); d) $\dot{v} \approx 8.12$ (m/s^2)
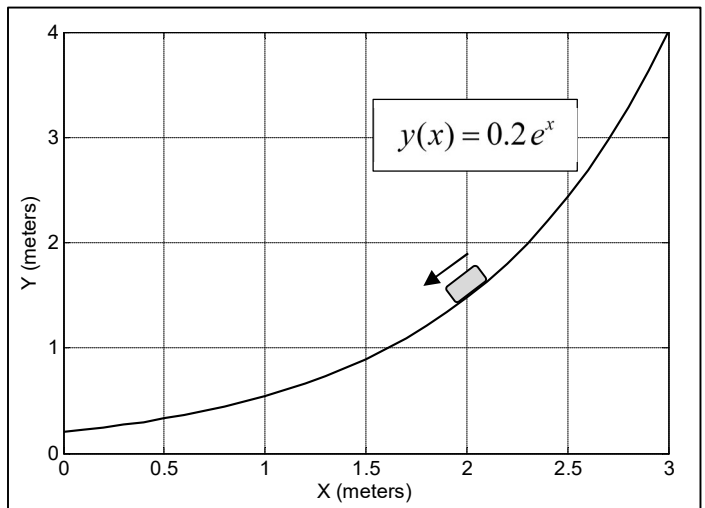
15. The 100 (kg) collar C is driven along a wire path in the **vertical** plane by the thrust force T. T is always **tangent** to the path, and the kinetic coefficient of friction between the collar and the wire path is $\mu_k = 0.3$. At the instant shown, the speed of the collar is $v_C = 5$ (m/s) and is **increasing** at a rate $\dot{v}_C = 20$ (m/s^2). 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) $\theta \approx 36.9$ (deg); b) $\rho \approx 6.51$ (m); c) $N \approx 1170$ (N), d) $T \approx 2940$ (N)
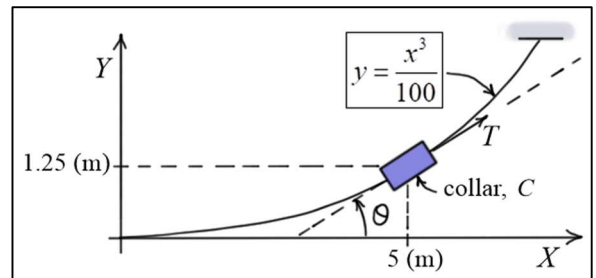
16. The small ball has mass $m = 0.5$ (kg), and it is confined to move along the **smooth vertical slot** due to the rotation of arm OA. The arm is rotating at a **constant rate** of $\dot\theta = 2$ (rad/s). At $\theta = 30$ (deg) find a) a_r and a_θ the **radial** and **transverse** components of the **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**.
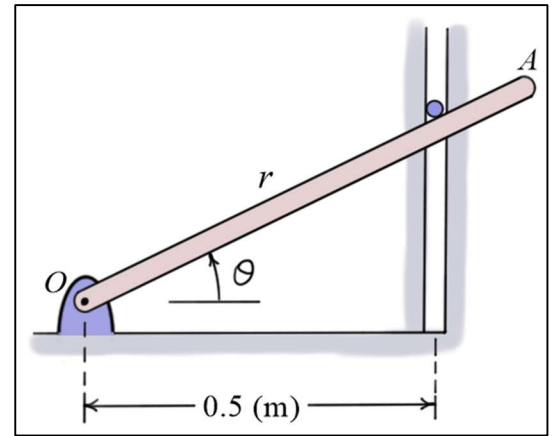
Answers:

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)