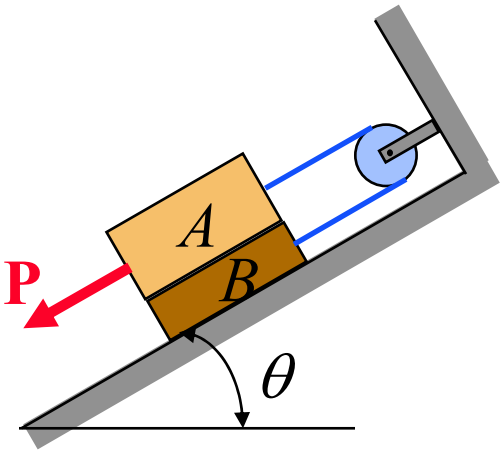
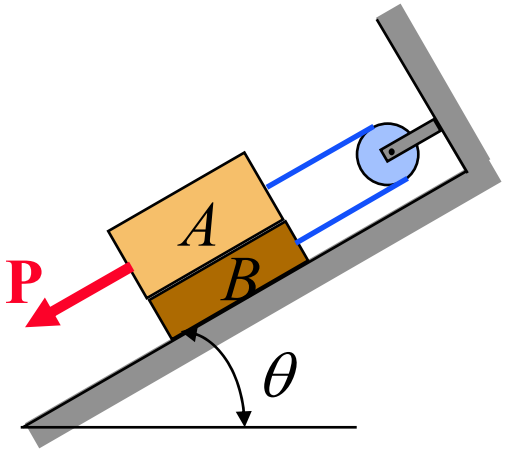
Problem 12.123



Block A has a mass of 30 kg and block B has a mass of 15 kg. The coefficients of friction between all plane surfaces of contact are $\mu_s = 0.15$ and $\mu_k = 0.10$. Knowing that $\theta = 30^\circ$ and that the magnitude of the force **P** applied to block A is 250 N, determine (a) the acceleration of block A , (b) the tension in the cord.

Problem 12.123

Solving Problems on Your Own



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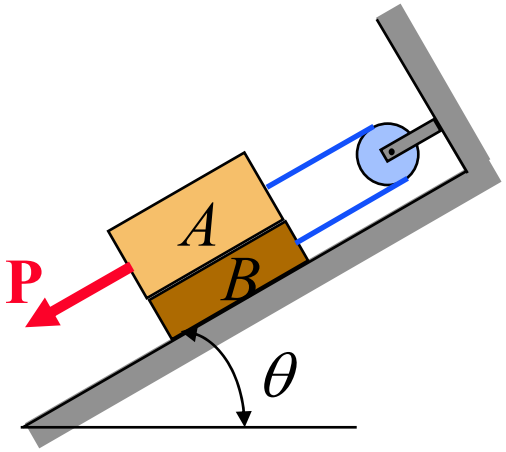
1. *Kinematics:* Examine the acceleration of the particles.

2. *Kinetics:* Draw a free body diagram showing the applied forces and an equivalent force diagram showing the vector $m\mathbf{a}$ or its components.

Problem 12.123

Solving Problems on Your Own



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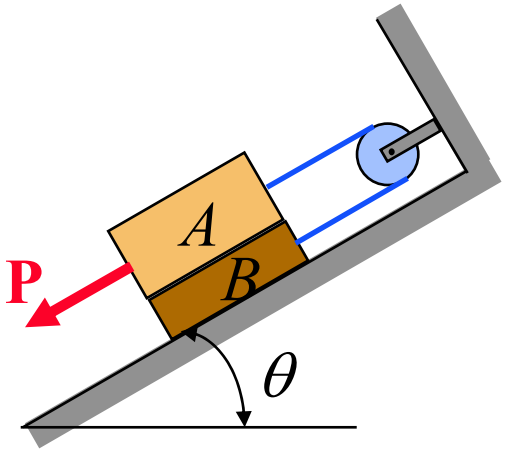
3. *When a problem involves dry friction:* It is necessary first to assume a possible motion and then to check the validity of the assumption. The friction force on a moving surface is $F = \mu_k N$. The friction force on a surface when motion is impending is $F = \mu_s N$.

Problem 12.123

Solving Problems on Your Own



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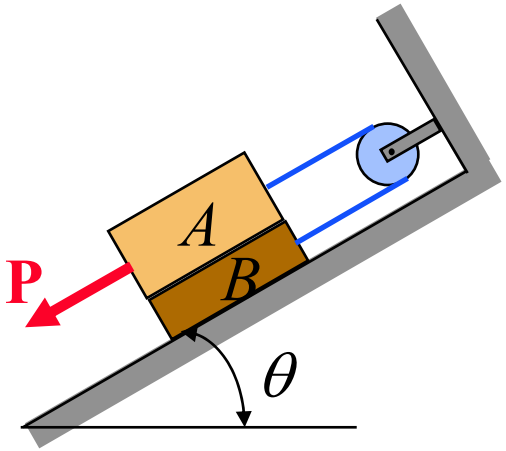
4. *Apply Newton's second law:* The relationship between the forces acting on the particle, its mass and acceleration is given by $\Sigma \mathbf{F} = m\,\mathbf{a}$. The vectors $\mathbf{F}$ and $\mathbf{a}$ can be expressed in terms of either their rectangular components or their tangential and normal components. Absolute acceleration (measured with respect to a newtonian frame of reference) should be used.

Problem 12.123 Solution

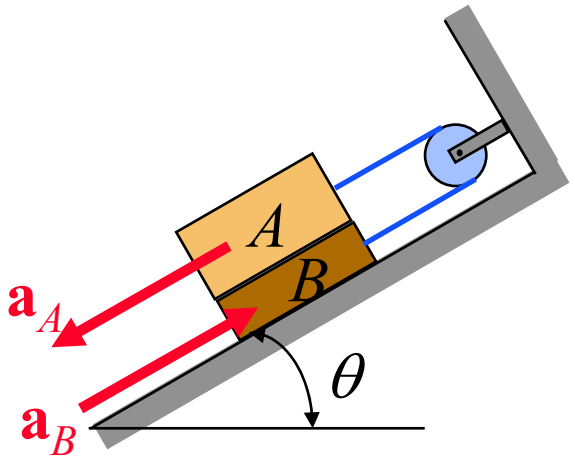
Kinematics.



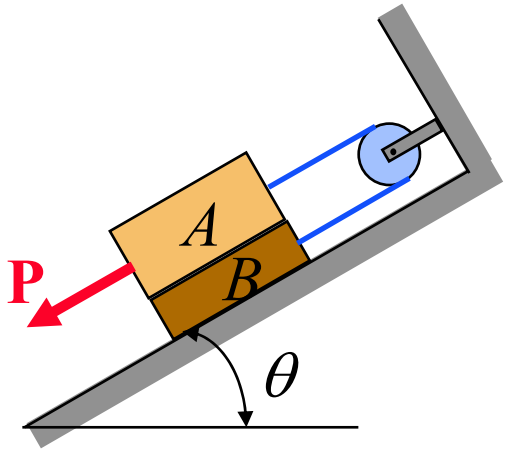
Assume motion with block A moving down.

If block A moves and accelerates down the slope, block B moves up the slope with the same acceleration.

$$a_A = a_B$$

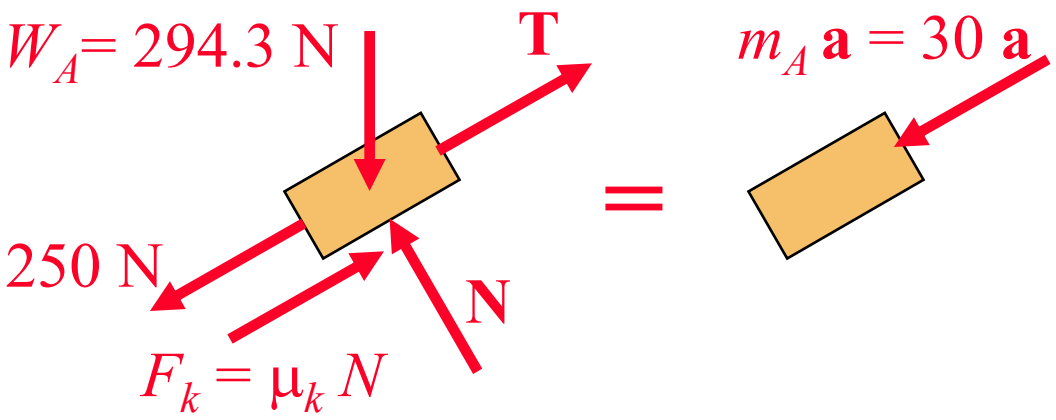


Problem 12.123 Solution



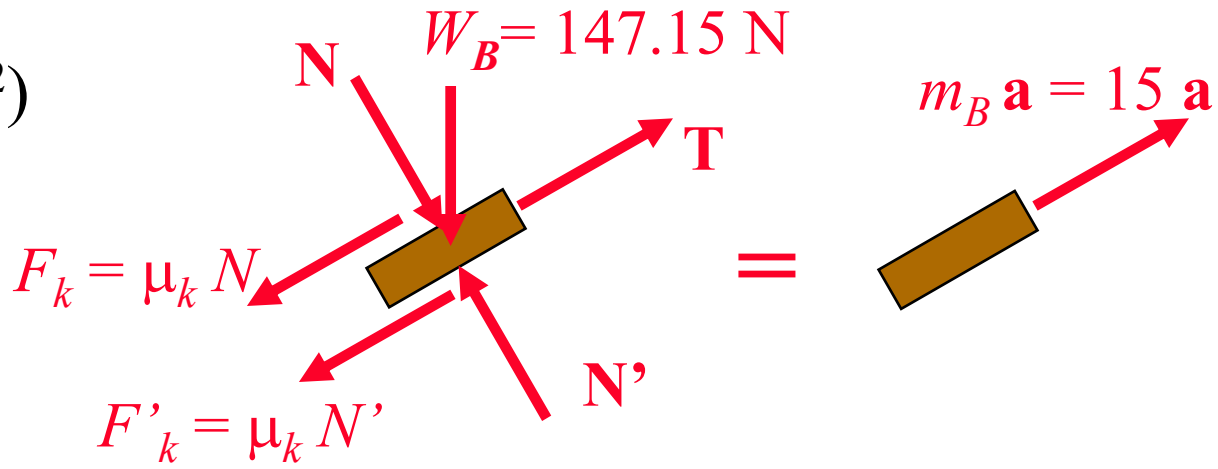
Kinetics; draw a free body diagram.

Block A :



$$W_A = m_A\,g$$
$$W_A = (30\text{ kg})(9.81\text{ m/s}^2)$$
$$W_A = 294.3\text{ N}$$

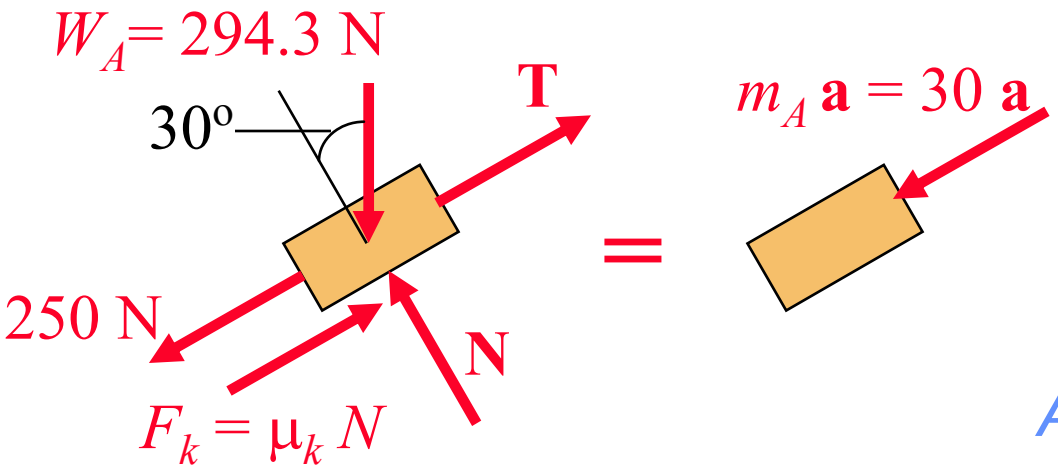
Block B :



$$W_B = m_B\,g$$
$$W_B = (15\text{ kg})(9.81\text{ m/s}^2)$$
$$W_B = 147.15\text{ N}$$

Problem 12.123 Solution

Block A :



Apply Newton's second law.

$+\nwarrow \Sigma F_y = 0$: N - (294.3) cos 30° = 0 N = 254.87 N

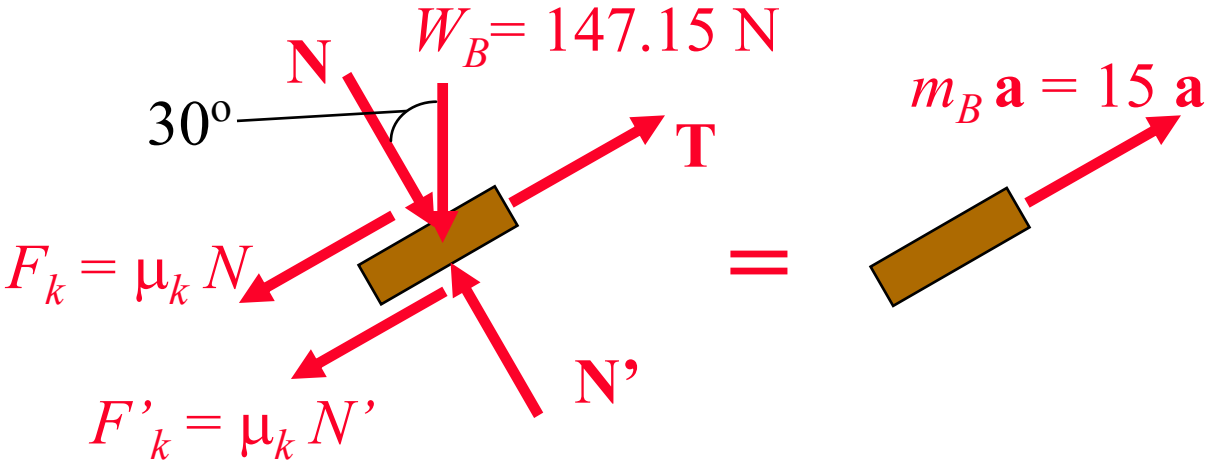
$F_k = \mu_k N = 0.10\ (254.9) = 25.49$ N

$+\swarrow \Sigma F_x = ma$: 250 + (294.3) sin 30° - 25.49 - T = 30 a

371.66 - T = 30 a (1)

Block B :

Problem 12.123 Solution



$+\nwarrow \Sigma F_y = 0$: $\quad N' - N - (147.15)\cos 30^\circ = 0 \qquad N' = 382.31$ N

$$F'_k = \mu_k N' = 0.10\,(382.31) = 38.23 \text{ N}$$

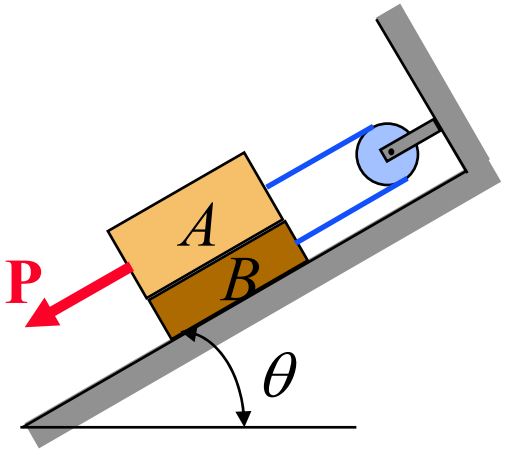
$+\nearrow \Sigma F_x = ma$: $\quad T - F_k - F'_k - (147.15)\sin 30^\circ = 15\,a$

$$T - 137.29 = 15\,a \qquad (2)$$

Solving equations (1) and (2) gives:

$T = 215$ N $\qquad$ **a** = 5.21 m/s^2 $\swarrow$

Problem 12.123 Solution



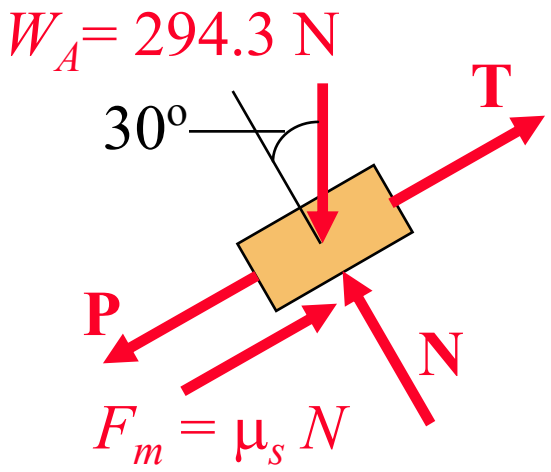
Verify assumption of motion.

Check: We should verify that blocks actually move by determining the value of the force **P** for which motion is impending

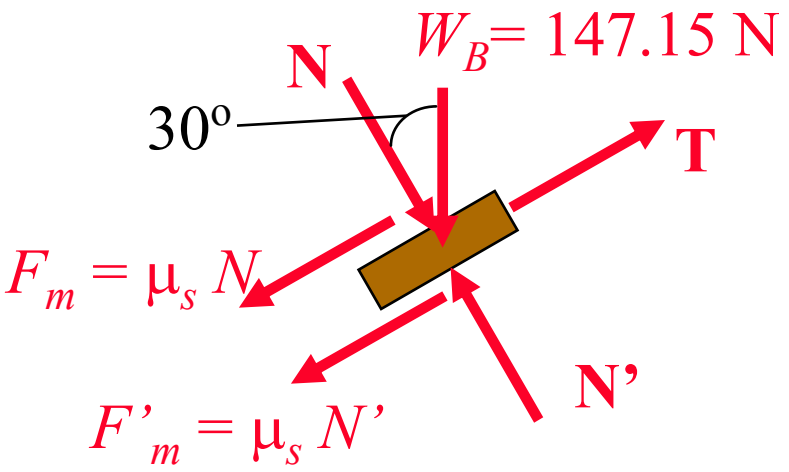
Find **P** for impending motion.

For impending motion both blocks are in equilibrium:

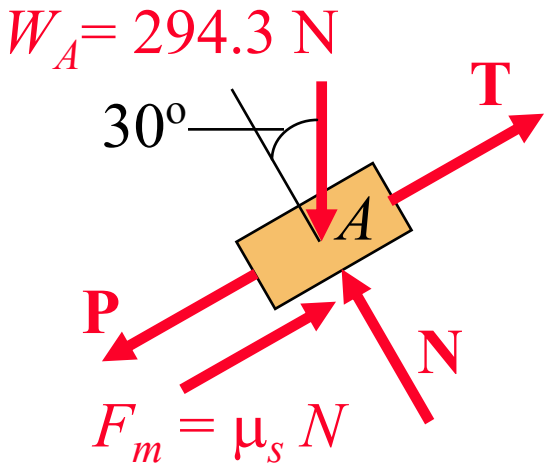
Block *A*

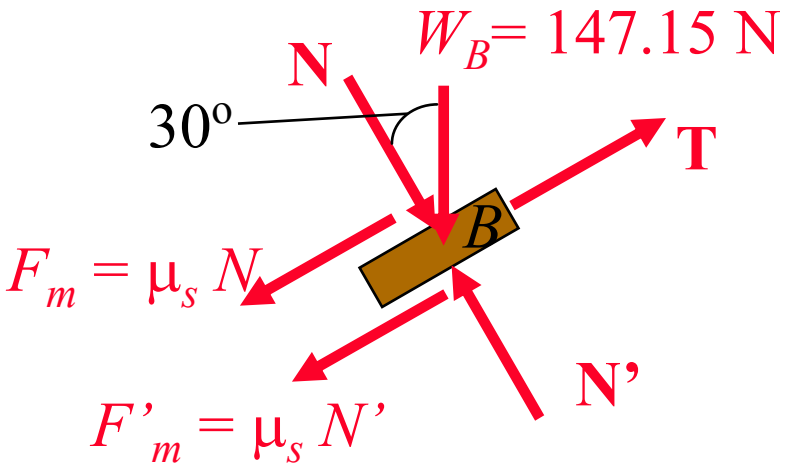


Block *B*



Problem 12.123 Solution





From $+\nwarrow \Sigma F_y = 0$ find again

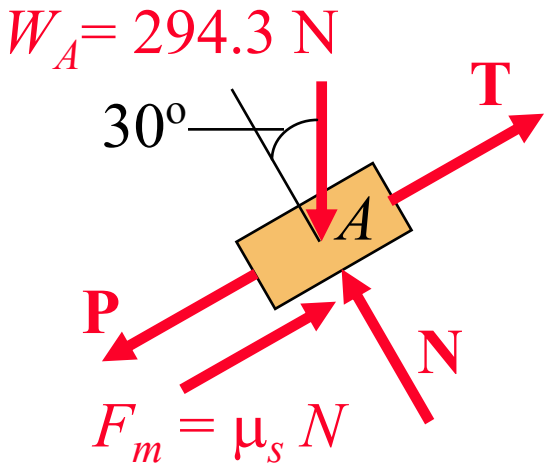
$$N = 254.87 \text{ N and } N' = 382.31 \text{ N},$$

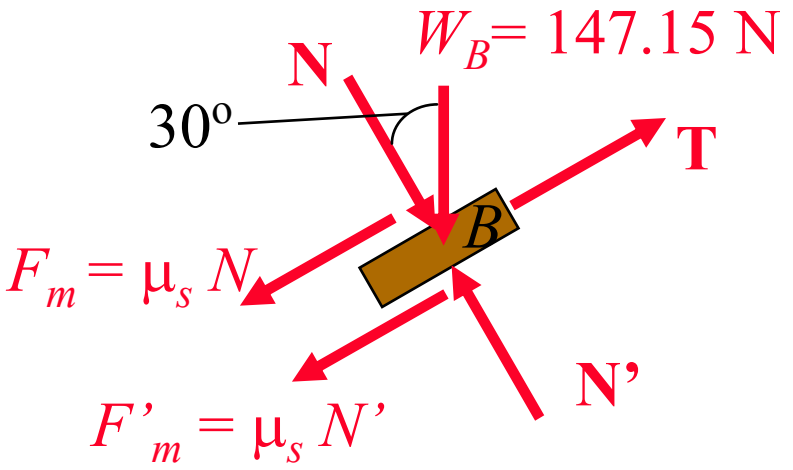
and thus

$$F_m = \mu_s N = 0.15\ (254.87) = 38.23 \text{ N}$$

$$F'_m = \mu_s N' = 0.15\ (382.31) = 57.35 \text{ N}$$

Problem 12.123 Solution





For block A:

$$+\swarrow \Sigma F_x = 0: \quad P + (294.3)\sin 30^\circ - 38.23 - T = 0 \qquad (3)$$

For block B:

$$+\nearrow \Sigma F_x = 0: \quad T - 38.23 - 57.35 - (147.15)\sin 30^\circ = 0 \qquad (4)$$

Solving equations (3) and (4) gives $P = 60.2$ N.

Since the actual value of P (250 N) is larger than the value for impending motion (60.2 N), motion takes place as assumed.