P1211 Pre-Midterm Lecture

Friday Oct 30, 2020

A Multiple choice

- A 40-N crate rests on a rough horizontal floor. A 12-N horizontal force is then applied to it. If the coefficients of friction are μ_s = 0.5 and μ_k = 0.4, the magnitude of the frictional force on the crate is:
- A) 8N B) 12 N C) 16N D) 20 N E) 40 N

F_s,max = 40N x 0.5 = 20 N so cannot overcome static friction

So force is 12N

Problem 2 as a short answer questions

In the diagram below, block A (100kg) is on a 30° incline is connected by a **frictionless** pulley to block B (50 kg) on a 53.1° incline. (a) Which way will the system move when released from rest. (b) What is the acceleration of the blocks? (c) What is the tension in the cord?

Short Answers Format In the diagram above, block A (100kg) is on a 30° incline is connected by a **frictionless** pulley to block B (50 kg) on a 53.1° incline.

A)Which way will the system move when released from rest? Briefly explain using physics concepts;

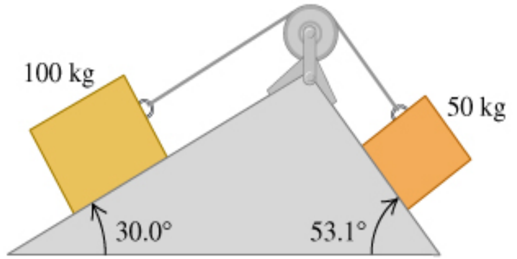
B) What are the forces acting on 50kg mass and what are their directions?

C) Use Newton's second law to find equation relating the force of part B to the acceleration;

D) What are the forces acting on 100kg mass and what are their directions?

E) Use Newton's second law to find equation relating the force of part D to the acceleration;

F) Find tension T and acceleration, a.



Variables:
Tension T; acceleration, a
Weight on 50 kg , F_g50
Weight on 100 kg, F_g100, Normal Force F_N

Problem 2 as a short answer questions: Part A and B and C.

<u>Short Answers Format</u> In the diagram below, block A (100kg) is on a 30° incline is connected by a **frictionless** pulley to block B (50 kg) on a 53.1° incline.

A)Which way will the system move when released from rest? Briefly explain using physics concepts;

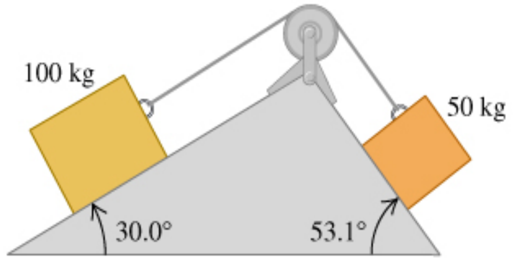
50 kg x g x sin 53.1 – 100 kg x g x sin 30 = -10g < 0. Hence 100 kg will slide down left incline

B) What are the forces acting on 50kg mass and what are their directions?

Gravity F_g50 down. And T up right incline, and normal force, F_N, perpendicular to incline

C) Use Newton's second law to find equation relating the force of part B to the acceleration;

-M_50 g sin 53.1 + T = + M_50 x a



<u>Variables</u>:
Tension T; acceleration, a
Weight on 50 kg , F_g50
Weight on 100 kg, F_g100, Normal Force F_N

Problem 2 as a short answer questions: Part D and E and F.

<u>Short Answers Format</u> In the diagram below, block A (100kg) is on a 30° incline is connected by a **frictionless** pulley to block B (50 kg) on a 53.1° incline.

D) What are the forces acting on 100kg mass and what are their directions?

Gravity F_g100 down, T up left incline and normal force, F_N, perpendicular to incline

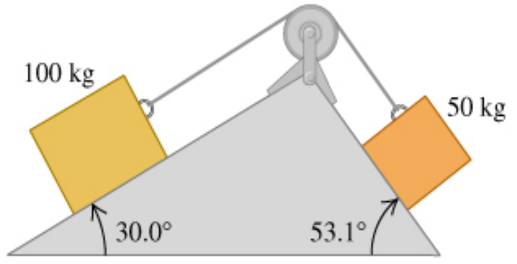
E) Use Newton's second law to find equation relating the force of part D to the acceleration;

M_100 g sin 30 – T = M_100 a

F) Find tension T and acceleration, a.

Add part C and E: M_100 x 0.5g - M_50 x 0.8 g = (M_100 + M_50) a, a = 0.65 m s^-2

Use part E, T = M_100 (0.5g - a) = 425 N



<u>Variables</u>:

Tension T; acceleration, a

Weight on 50 kg , F_g50

Weight on 100 kg, F_g100, normal force F_N

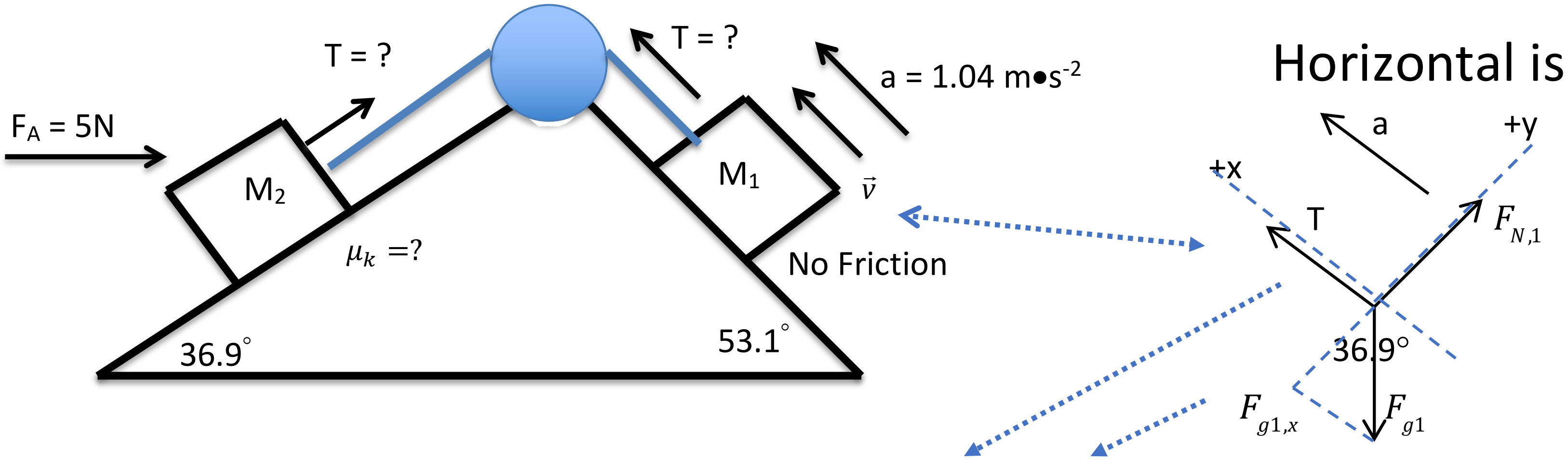
Problem 4, Practice

In the diagram, box 1(M_1=2kg) lies on **frictionless incline** of 53.1°, and is **moving up** the incline with acceleration a = 1.04 m•s^{-2}. Box 1 is connected by an ideal rope through a frictionless pulley to box 2 (M_2=7kg), which rests on a 36.9° incline with friction. Block 2 is acted on by a horizontal force of magnitude F_A = 5N. The **tension** (T = ?) and **kinetic coefficient** (μ_k) are **unknown**

A) Draw a free-body-diagram (FBD) of all forces on block 1 (M_1), which includes the direction of its acceleration. **Calculate** the **tension**, T

Since there is no friction on this side, only the

Horizontal is important x-component:



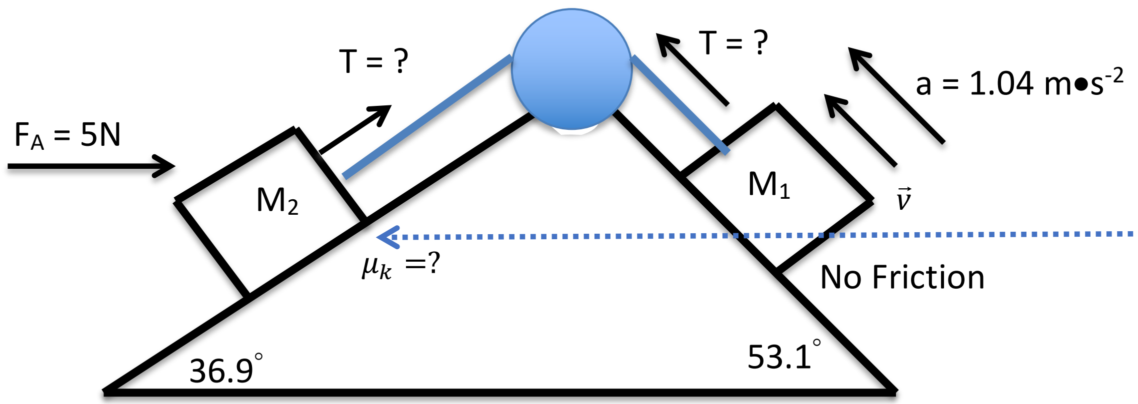
$$F_{net1,x} = T + F_{g1,x} = M_1 a \rightarrow T = M_1 g \sin 53.1^\circ + M_1 a$$

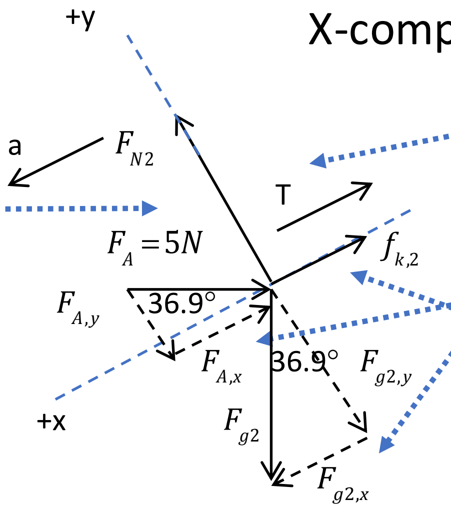
$$T = 2kg \times 9.8 m \bullet s^{-2} \times 0.8 + 2kg \times 1.04 m \bullet s^{-2} = 17.76N$$

Problem 4, Practice

In the diagram, box 1(M_1=2kg) lies on **frictionless incline** of 53.1°, and is **moving up** the incline with acceleration a = 1.04 m•s^{-2}. Box 1 is connected by an ideal rope through a frictionless pulley to box 2 (M_2=7kg), which rests on a 36.9° incline with friction. Block 2 is acted on by a horizontal force of magnitude F_A = 5N. The **tension** (T = ?) and **kinetic coefficient** (μ_k) are **unknown**

Draw a free-body diagram (FBD) of all forces acting on block 2 (M_2). Use this to determine the **magnitude** and **direction** of the friction force $f_{k,2}$, acting on block 2. Calculate the **coefficient** of **kinetic friction**, μ_k, between surfaces of block 2 and incline





X-comp: $F_{Net,x} = F_{g2,x} - T + F_{Ax} - f_{k,2} = M_2 a$

$F_{g2,x} = M_2 g \sin 36.9^\circ = 41.16N,$

$F_{A,x} = -F_A \cos 36.9^\circ = -4N,$

$f_{k,2} = F_{g2,x} - T + F_{Ax} - M_2 a$

T = 17.76N

$$f_{k,2} = 41.16N - 17.76N - 4N - 7kg \times 1.04m \cdot s^{-2} = 12.12N$$

Y-component: $F_{net2,y} = F_{N2} + F_{A,y} + F_{g2,y} = 0$

$$F_{N2} = -F_{A,y}. \quad -F_{g2,y}$$

$$F_{N2} = 5N \cos 36.9^\circ + 7kg \times 9.8m \cdot s^{-2} \sin 36.9^\circ$$

Friction: $f_{k2} = \mu_k F_{N2} \rightarrow \mu_k = 12.12N / 57.88N = 0.21$

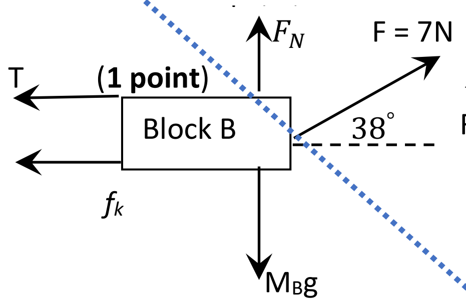
Problem 5: Part A, B and C

Part A to C is from 2019 midterm 2. Below block A has a mass of 8.00 kg and block B has mass 4.00 kg. Block A is moving right with a **speed** of v = 3.0 m/s to the **right**. A force F = 7 N is applied at 38° to the horizontal. Friction coefficients of blocks and the table: $\mu_k = 0.14, \mu_s = 0.26$.

A) Draw a free-body diagram of **Block B**, which includes the **five** forces acting on it, and its acceleration, a. Use Newton's law to derive an equation that relates two **unknowns**: **tension** of the rope, T; **acceleration**, a.

B) Draw a free-body diagram of **Block A**, which includes the **four** forces acting on it, and its acceleration, a. Use **Newton's law** to derive an equation that relates two **unknowns**: the **tension** of the rope, T, and the **acceleration**, a.

C) Solve the equations from part **A)** and **B)** to find T and a. How long does it take **Block B** travel **0.8 m** to reach the edge of the table?



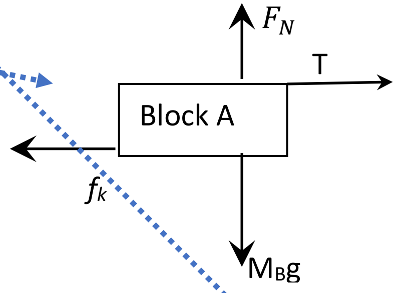
Y-com, $F_{Net,y} = F_N + F sin38^{\circ} - M_B g = 0$

$F_N = 4kg \times 9.8\frac{m}{s^2} - 7N \times sin38^{\circ} = 34.9N$

Friction: $f_k = F_N \mu_k = 34.9N \times 0.14 = 4.88$ (**2 points**)

X-Com $F_{Net,x} = F cos38^{\circ} - f_k - T = M_B a$

$5.5N - 4.88N - T = 4kg \times a$ [1] (**1 point**)



Y-com, $F_{Net,y} = F_N - M_A g = 0$

$F_N = 8kg \times 9.8\frac{m}{s^2} = 78.4N$

Friction: $f_k = F_N \mu_k = 10.97N \times 0.14 = 10.97N$

X-Com $F_{Net,x} = T - f_k = M_A a$

$T - 10.97N = 8kg \times a$ [2]

Adding both side of 1 and 2, $-10.35N = 12kg \times a$

$a = -0.86\frac{m}{s^2}$ (**1 point**)

The acceleration is to the left, since a < 0.

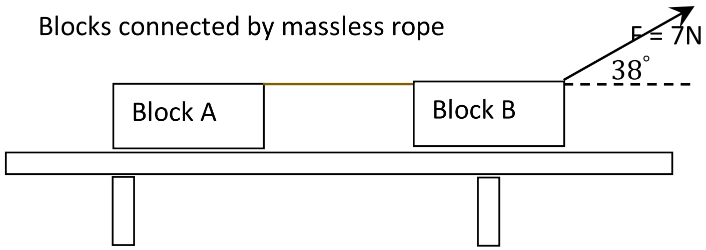
Time to edge, $x = v_0 t + \frac{1}{2}at^2 \rightarrow 0.8m = 3\frac{m}{s}t - \frac{1}{2}0.86\frac{m}{s^2}t^2$

$$0 = \frac{m}{s^2}t^2 - 6.977\frac{m}{s}t + 1.86m \rightarrow t = \frac{6.977 \pm \sqrt{(6.977)^2 - 4(1.86)}}{2}$$

t = 0.278s or 6.69s. Physical solution is 0.278s. (**1 point**)

$T - 10.97N = 8kg \times a \rightarrow T = 4.09N$ or $7N \times cos38^{\circ} - 4.88N - T = 4kg \times a$

Blocks connected by massless rope



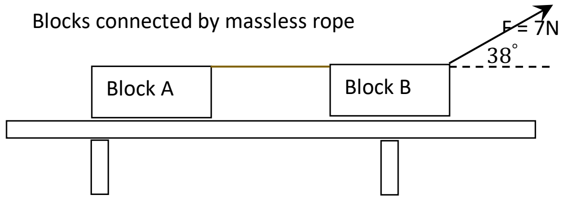
Problem 5: Part D

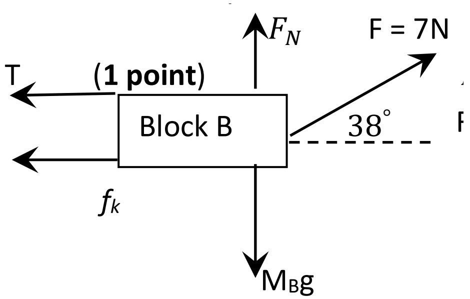
Part A to C is from 2019 midterm 2. Below block A has a mass of 8.00 kg and block B has mass 4.00 kg. Block A is moving right with a **speed** of **v = 3.0 m/s** to the **right**. A force F = 7 N is applied at 38° to the horizontal. Friction coefficients of blocks and the table: $\mu_k = 0.14, \mu_s = 0.26$.

D) Calculate the total work done on the system and find the speed after it travels 0.8 m.

From earlier, $T = 4.09N$ and $a = -0.86\frac{m}{s^2}$ and $f_{kB} = F_N\mu_k = 34.9N\times 0.14 = 4.88N$

$F_x = F\cos 38^{\circ} = 5.5N$, $f_{kA} = F_N\mu_k = 10.97N$



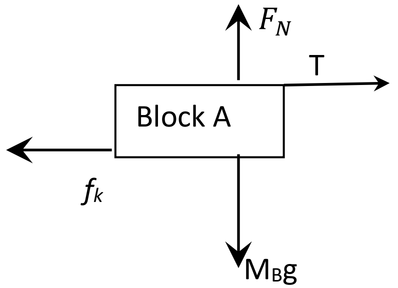


Block B

$$W_B = F_x\times 0.8m - T\times 0.8m - f_{kB}\times 0.8m = -2.776J$$

Use Work-energy to find final speed

$$W_B = \Delta K = \frac{1}{2}m_B v_f^2 - \frac{1}{2}m_B v_i^2 \rightarrow v_f = 2.76\frac{m}{s}$$



Block A

$$W_A = T\times 0.8m - f_{kA}\times 0.8m = -5.504J$$

$$W_A = \Delta K = \frac{1}{2}m_A v_f^2 - \frac{1}{2}m_A v_i^2 \rightarrow v_f = 2.76\frac{m}{s}$$

System A + B + massless rope

$$W_A + W_B = -8.28J = \frac{1}{2}m_A v_f^2 + \frac{1}{2}m_B v_f^2 - \frac{1}{2}m_A v_i^2 - \frac{1}{2}m_B v_i^2 \rightarrow v_f = 2.76\frac{m}{s}$$