# Group Quiz 5

Group Number: Names: Answer Key

Date:

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[15 points total] In both problems below, you are given a block of mass $M$ on a given surface with friction between them. The empirical formula for kinetic friction is

$$F_k = \mu_k N$$

where $N$ is the normal force and $\mu_k$ is the coefficient of kinetic friction.

In the given diagrams, the red dot indicates the block's center of mass. You can use these facts:

- $g = 9.80\,\mathrm{m/s^2}$ is the gravitational acceleration.
- $M = 3.50\,\mathrm{kg}$ is the mass of the block.
- $m$ is the mass of the hanging block (problem 2), which is to be determined.
- $\mu_k$ is the coefficient of kinetic friction between the block of mass $M$ and the surface.
- Disregard effects due to the air.
- Assume the string and the pulley are both ideal.

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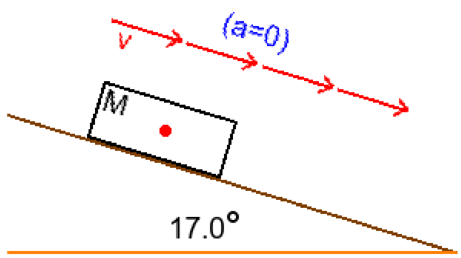
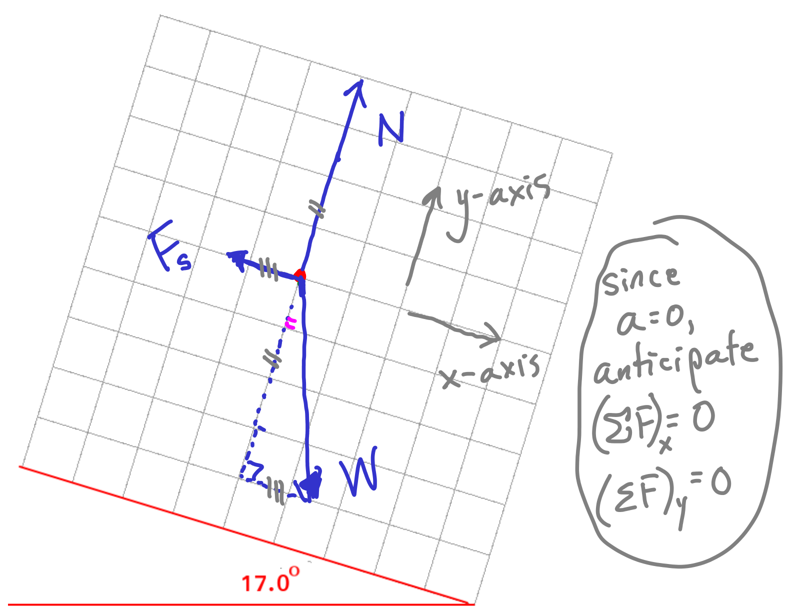
**(1)** [6 total] When the surface is tipped up to an angle of $\theta = 17.0°$, and the block given a gentle push, it slides down with a constant speed as illustrated below. This is a unique angle, when set to any other angle (from 0° to 90°), it will not move with a constant speed when given a gentle nudge.




/1 **(1.a)** In the grid space above right, construct a free body diagram (or force diagram) for the sliding mass. This should also include a coordinate system.

/3 **(1.b)** Apply Newton's second law in component form for the sliding mass. This should include two equations.

$(\Sigma F)_x = W_x + F_{sx} + N_x = m a_x$ ($a_x \to 0$)

$W \sin\theta - F_s + (0) = (0)$

$$F_s = W \sin\theta$$

$(\Sigma F)_y = W_y + F_{sy} + N_y = m a_y$ ($a_y \to 0$)

$-W\cos\theta + (0) + N = 0$

$$N = W\cos\theta$$

/1 **(1.c)** Using those equations and the kinetic friction law, derive a formula for the coefficient of kinetic friction $\mu_k$ in terms other measured or given quantities.

equal

$$\mu_k = \frac{F_s}{N} = \frac{W \sin\theta}{W \cos\theta} = \tan\theta$$

$\mu_k$= $\tan\theta$ (formula)

/1 **(1.d)** Compute the value of $\mu_k$ precise to three significant figures.

with $\theta = 17^\circ$, $\tan 17^\circ = 0.30573\ldots$

$\mu_k$= $0.306$ (number)

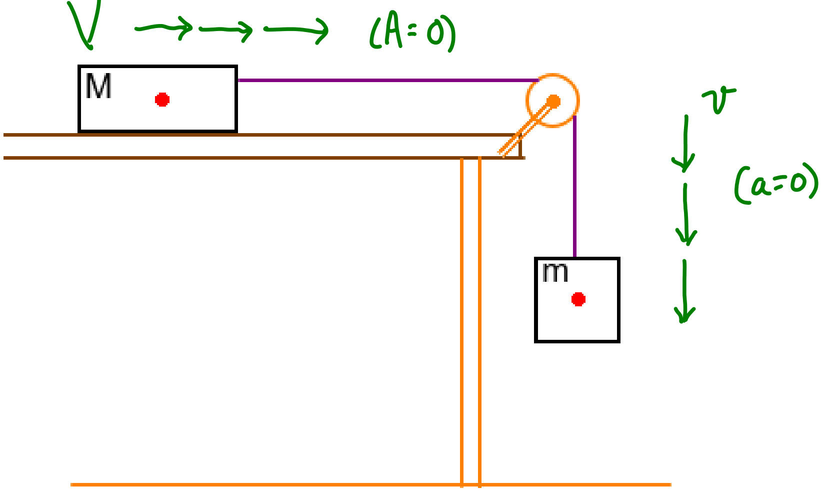
(if you get $\tan 17 = 3.493\ldots$, you are in radian mode)

[Problem 2 is on next page.]

**(2)** [9 total] We now use the same block and surface, but this time it is level. We attach another mass $m$ using an ideal string and an ideal pulley as shown below. The mass $m$ hangs over the edge of the table.

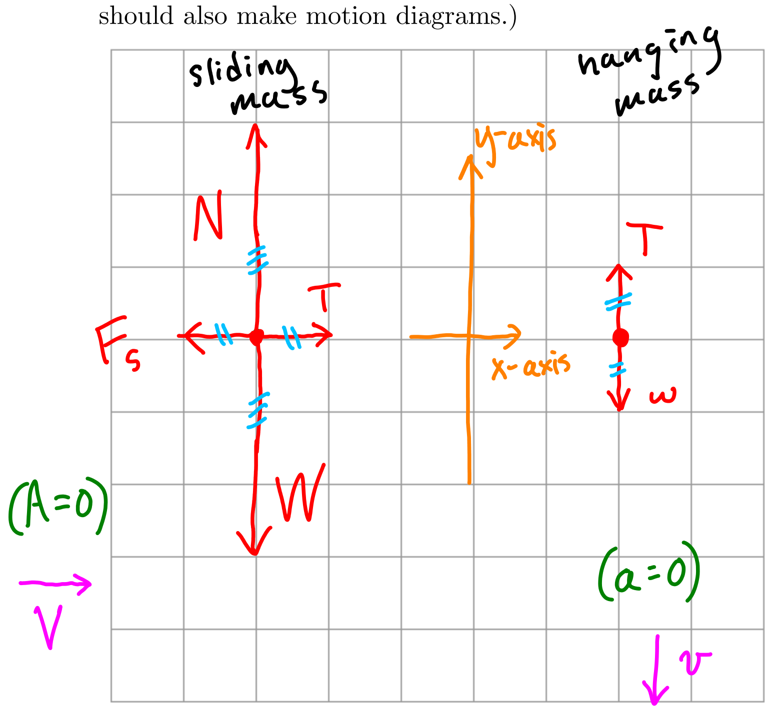
When we let go and give the block $M$ a little push to the right, they are observed to move with a constant speed. When a different mass $m$ is hanging, they will not move at a constant speed.

In this problem, use the same value of $\mu_k$ you had in problem 1. Your task is now to figure out the value of $m$ that will give the situation of constant speed described above.




$\mu_k = 0.306$ from previous problem

/2 **(2.a)** Construct free body diagrams (or force diagrams) for the sliding mass and the hanging mass. This should also include a coordinate system. Your diagrams should also include coordinate axes. (You should also make motion diagrams.)




We know a=0 for both, so both experience no net force. Use that information when constructing the force diagrams.

/4 **(2.b)** Apply Newton's second law in component form for the sliding mass (two equations) and the hanging mass (one equation).

sliding mass

$(\Sigma F)_x = T - F_s = 0$

$T = F_s$

$(\Sigma F)_y = N - W = 0$

$N = W$

hanging mass

$(\Sigma F)_y = T - w = 0$

$T = w$

same T

$F_s = T = w = mg$ $N = W = Mg$

/2 **(2.c)** Using those equations and the kinetic friction law, derive a formula for the coefficient for the hanging mass $m$ in terms other measured or given quantities.

$$\mu_k = \frac{F_s}{N} = \frac{mg}{Mg} = \frac{m}{M} \Rightarrow m = \mu_s M$$

$m =$ $\mu_s M$ (formula)

/1 **(2.d)** Compute the value of $m$ precise to three significant figures.

$m = \mu_s M = (0.306)(3.50) =$

(0.306: from prob 1; 3.50: given in prob statement)

$m =$ 1.07 kg (number)

[Done.]