

First Name: \_\_\_\_\_

Last Name: \_\_\_\_\_

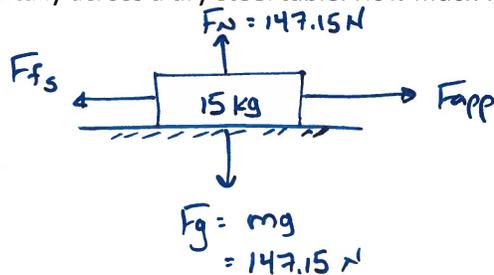
**1.04 - Worksheet - Friction in 1-Dimension**

Use the following information to answer Q1-Q9:

Material	Coefficient of Static Friction $\mu_s$	Coefficient of Kinetic Friction $\mu_k$
Copper on copper	1.6	1.0
Steel on dry steel	0.41	0.38
Steel on greased steel	0.15	0.09
Dry oak on dry oak	0.5	0.3
Rubber tire on dry asphalt	1.2	0.8
Rubber tire on wet asphalt	0.6	0.5
Rubber tire on dry concrete	1.0	0.7
Rubber tire on wet concrete	0.7	0.5
Rubber tire on ice	0.006	0.005
Curling stone on ice	0.003	0.002
Teflon™ on Teflon™	0.04	0.04
Waxed hickory skis on dry snow	0.06	0.04
Waxed hickory skis on wet snow	0.20	0.14
Synovial fluid on joint	0.01	0.01

Q1: A 15kg steel block is being dragged horizontally across a dry steel table. How much force is required to get the object moving?

- a.  $F \leq 60.3315 \text{ N}$
- b.  $F = 60.3315 \text{ N}$
- c.  $F \geq 60.3315 \text{ N}$
- d.  $F > 60.3315 \text{ N}$**



$$\begin{aligned}
 F_{fs} &\leq \mu_s F_n \\
 &\leq (0.41)(147.15 \text{ N}) \\
 &\leq 60.3315 \text{ N}
 \end{aligned}$$

Applied force  $> 60.3315 \text{ N}$  to get it moving (i.e. overcome static friction).

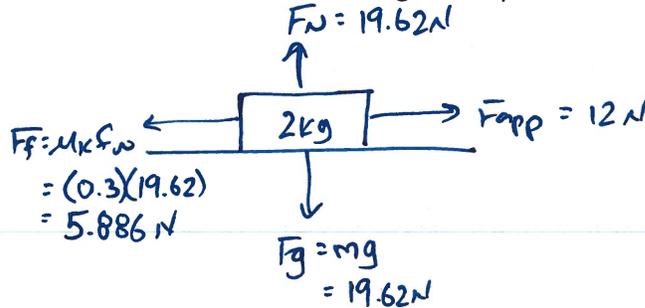
KEY

Use the following additional information to answer Q2-Q3:

A 2kg dry oak plank is being dragged horizontally across a dry oak table with a force of 12 Newtons.

Q2: What is the magnitude of the frictional force acting on the plank?

- a. 0.60 N
- b. 5.89 N
- c. 9.81 N
- d. 19.62 N



Q3: The acceleration of the oak plank is \_\_\_\_\_  $\text{m/s}^2$ ,

(Record your **three-digit** answer in the Numerical Response boxes below)

3.06

$$\begin{aligned}\vec{F}_{net} &= \vec{F}_{app} + \vec{F}_k \\ &= (12.0\text{ N}) + (-5.886\text{ N}) \\ &= 6.114\text{ N}\end{aligned}$$

$$a = \frac{F_{net}}{m} = \frac{6.114\text{ N}}{2\text{ kg}} = 3.057\text{ m/s}^2$$

$$a \approx 3.06\text{ m/s}^2$$

■ KEY ■

Use the following additional information to answer Q4-Q6:

An 18kg curling stone is thrown at  $0.65 \text{ m/s}^2$  across the ice. The curling stone moves 10 meters before hitting the walkway and stopping.

Q4: The force of friction acting on the curling rock is  $a.bc \times 10^{-d} \text{ N}$ , where  $a, b, c$ , and  $d$  are \_\_, \_\_, \_\_, and \_\_.

(Record your four-digit answer in the Numerical Response boxes below)

3 5 3 1

$F_f = \mu_k F_n$   
 $= (0.002)(176.58)$   
 $= 0.35316 \text{ N}$   
 $F_f \approx 3.53 \times 10^{-1} \text{ N}$

Q5: The deceleration of the rock is  $a.bc \times 10^{-d} \text{ m/s}^2$ , where  $a, b, c$ , and  $d$  are \_\_, \_\_, \_\_, and \_\_.

(Record your four-digit answer in the Numerical Response boxes below)

1 9 6 2

$$a = \frac{F_{\text{net}}}{m} = \frac{0.35316 \text{ N}}{18 \text{ kg}} = 0.01962 \text{ m/s}^2$$

$$a \approx 1.96 \times 10^{-2} \text{ m/s}^2$$

Q6: The speed of the curling stone prior to hitting the walkway is  $a.bc \times 10^{-d} \text{ m/s}$ , where  $a, b, c$ , and  $d$  are \_\_, \_\_, \_\_, and \_\_.

(Record your four-digit answer in the Numerical Response boxes below)

1 7 4 1

$$v_f^2 = v_i^2 + 2ad$$

$$= (0.65)^2 + 2(-0.01962)(10)$$

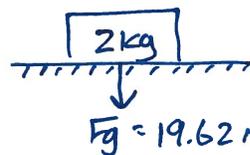
$$= 0.4225 - 0.3924$$

$$= 0.0301$$

$$v_f = 0.1735 \text{ m/s}$$

$$v_f \approx 1.74 \times 10^{-1} \text{ m/s}$$

1/4/14



$$F_{fk} = \mu_k F_N \\ = (1.0)(19.62) \\ = 19.62 \text{ N}$$
$$F_{fs} = \mu_s F_N \\ = (1.6)(19.62) \\ = 31.392 \text{ N}$$

Use the following additional information to answer Q7-Q9:

A 2kg copper block is sitting on a copper bench. An increasing force is applied to the block.

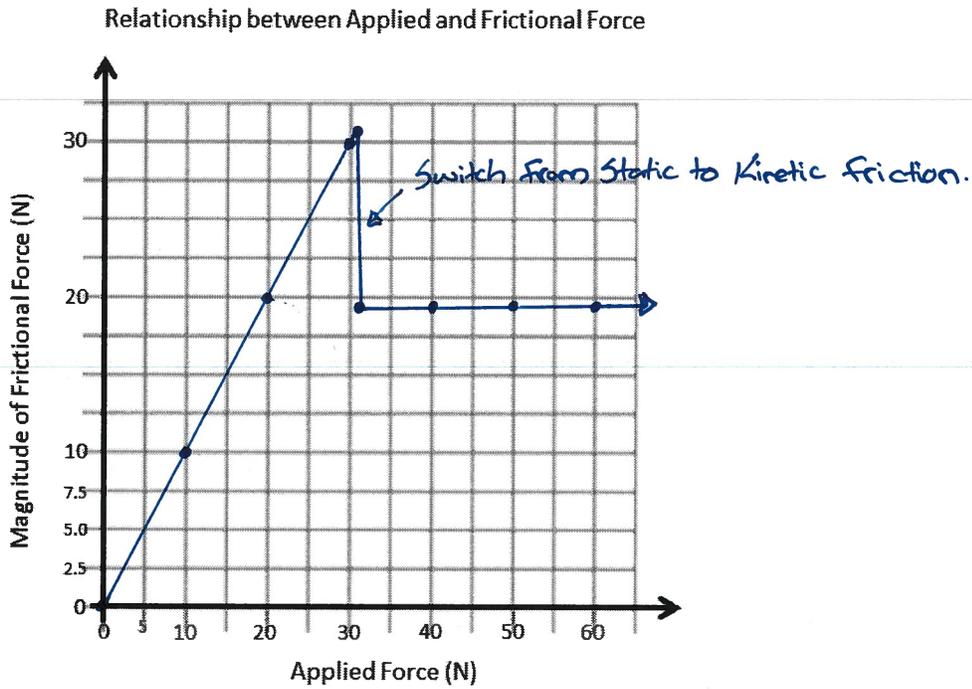
Q7: Complete the following table:



Applied Force (N)	Magnitude of Frictional Force (N)	Net Force (N)	Acceleration (m/s <sup>2</sup> )
0	0	0	0
10	-10	0	0
20	-20	0	0
30	-30	0	0
40	-19.62	20.38	10.19
50	-19.62	30.38	15.19
60	-19.62	40.38	20.19

■ KEY ■

Q8: Graph the relationship between applied and frictional force.



Q9: Graph the relationship between applied force and acceleration for a system with friction.

