# Physics 11

## Friction and Systems of Masses Worksheet

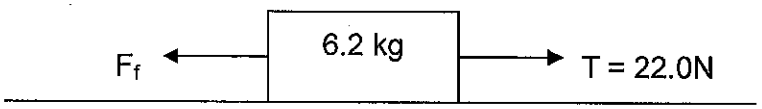
**Name:** _____ **Date:** _____

1. A 9.6 kg object is pulled along a horizontal surface. If the coefficient of friction between the surfaces is 0.11, what is the force of friction?

2. A 20.0 N object is placed on a horizontal surface. A force of 3.0 N is required to keep the object moving at a constant speed, what is the coefficient of friction between the two surfaces?

3. A 16.2 kg object is pulled along a frictionless horizontal surface by a horizontal net force of 10.2 N. What is the normal force acting on the object?

4. A 6.2 kg object is pulled along a horizontal surface as shown in the diagram by a force of 22.0 N. If the acceleration of the object is 1.1 $m/s^2$, what is the coefficient of friction between the surfaces?




5. A dockworker loading crates on a ship finds that a 20.0 kg crate, initially at rest on a horizontal surface, requires a 75 N horizontal force to set it in motion. However, after the crate is in motion, a horizontal force of 60 N is required to keep it moving with a constant speed.
   a. Find the coefficient of static friction between the crate and the floor.
   b. Find the coefficient of kinetic friction between the crate and the floor.

6. A hockey puck is given an initial speed of 20.0 m/s on a frozen pond. The puck remains on the ice and slides 120 m before coming to rest. Determine the coefficient of kinetic friction between the puck and the ice.

7. A 64 kg box is resting on a carpet floor. If the coefficient of static friction between the box and floor is 0.98, what force is required to put the box in motion?

8. A car whose brakes are locked skids to a stop in 70 m from an initial velocity of 80 km/h. Find the coefficient of kinetic friction.

9. A truck moving at 100 km/h carries a steel girder that rests on its wooden floor. What is the minimum time in which the truck can come to a stop without the girder moving forward? The coefficient of static friction between steel and wood is 0.5.

10. A box weighing 600 N is pushed along a horizontal floor at a constant

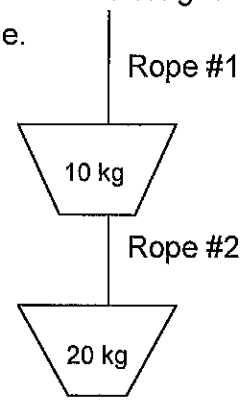
velocity by a force of 250 N parallel to the floor. What is the coefficient of friction between the box and the floor?

11. The coefficient of static friction between the tires of a car and a horizontal road is 0.60. If the net force on the car is the force of static friction exerted by the road,
    a. What is the maximum acceleration of the car?
    b. What is the shortest stopping distance possible if the car has an initial speed of 30 m/s?

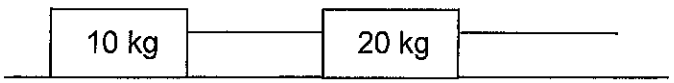
12. A 25 kg sign hangs outside a restaurant and is being held by two cables. Determine the tension forces in each cable.
    (Hint: the weight is distributed evenly between the two cables)

13. A 30.0 kg block is pulled along a table surface by a rope. If the table surface has a $\mu = 0.18$, what applied force (the tension force) is the rope necessary to accelerate the block at 1.5 $m/s^2$?

14. Two buckets are at rest as arranged in the diagram below. Determine the tension in each rope.

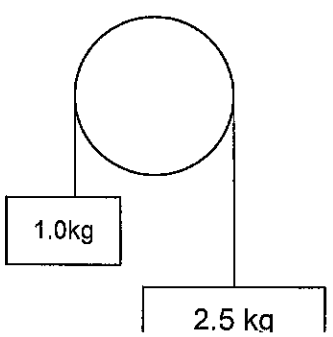



15. What is the tension in the rope that joins the two blocks that are pulled by a constant force of 500 N in the diagram below?

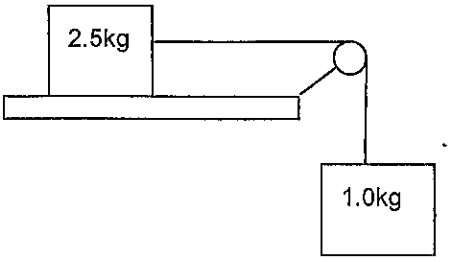



16. Given the following diagrams determine the $F_{net}$ and the acceleration of the acceleration of the system. Then find the tension in each cable that connects the masses. Consider the pulleys and tabletops to be frictionless.

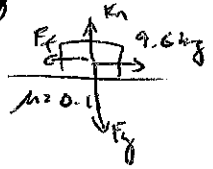
a.




b.



# ...ion and Systems of Masses Worksheet (KEY)

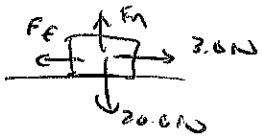



$F_g = mg = (9.6)(9.8) = 94.1\,N$

$F_n = 94.1\,N$

$F_\epsilon = \mu F_n = (0.11)(94.1) = 10.3\,N$

2)



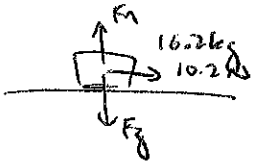

$F_n = 20.0\,N$

$F_\epsilon = 3.0\,N$

$F_\epsilon = \mu F_n \rightarrow \mu = \frac{F_\epsilon}{F_n} = \frac{3.0}{20.0} = 0.15$

const speed

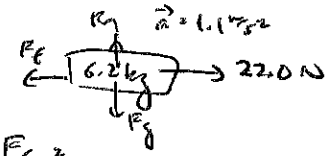
3)




$F_g = mg = (16.2)(9.8) = 159\,N$

$F_n = 159\,N$

4)




$F_g = mg = (6.2)(9.8) = 61\,N$

$F_n = 61\,N$

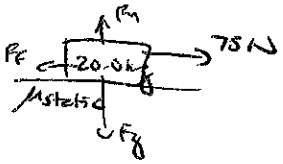
$F_{net} = ma = (6.2)(1.1) = 6.82\,N$

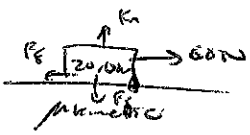
$F_{net} = T - F_\epsilon$

$6.82 = 22.0 - F_\epsilon$

$F_\epsilon = 22.0 - 6.82 = 15.2\,N$

5)




$F_g = mg = (20.0)(9.8) = 196\,N$

$F_n = 196\,N$

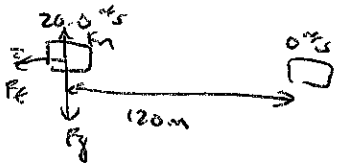
$F_\epsilon = 75\,N$

$\mu_s = \frac{F_\epsilon}{F_n} = \frac{75}{196} = 0.383$

$F_\epsilon = 60\,N$

$\mu_k = \frac{F_\epsilon}{F_n} = \frac{60}{196} = 0.306$

6)




$V_f^2 = V_i^2 + 2ad$

$(0)^2 = (20.0)^2 + 2a(120)$

$0 = 400 + 240a$

$-240a = 400$

$a = -1.67\ m/s^2$

$F_{net} = ma$

$F_\epsilon = m(-1.67)$

$F_\epsilon = -1.67m$

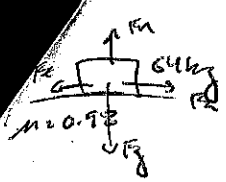
$F_g = mg$

$F_g = m(9.8)$

$F_g = 9.8m$

$F_n = 9.8m$

$\mu = \frac{F_\epsilon}{F_n} = \frac{+1.67m}{9.8m} = 0.170$



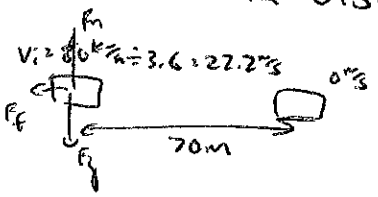

$F_g = mg = (64)(9.8) = 627\,N$

$F_n = 627\,N$

$F_f = \mu F_n = (0.98)(627) = 615\,N$

$F_f = 615\,N$

8)




$V_f^2 = V_i^2 + 2ad$

$(0)^2 = (22.2)^2 + 2a(70)$

$0 = 494 + 140a$

$-140a = 494$

$a = -3.53\,m/s^2$

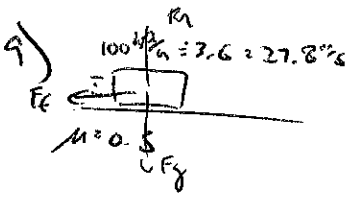
$F_g = mg = m(9.8) = 9.8m$

$F_n = 9.8m$

$\mu = \frac{F_f}{F_n} = \frac{3.53m}{9.8m} = 0.36$

$F_{net} = ma = m(-3.53) = -3.53m\ (= F_f)$

9)




$F_g = mg = m(9.8) = 9.8m$

$F_n = 9.8m$

$F_f = \mu F_n = (0.5)(9.8m) = 4.9m$

$(F_f =)\ F_{net} = ma$

$4.9m = ma$

$4.9\,m/s^2 = a$

$V_f = V_i + at$

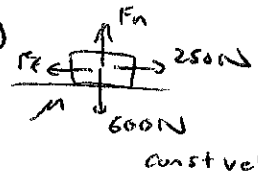
$(0) = (27.8) + (-4.9)t$

$0 = 27.8 - 4.9t$

$4.9t = 27.8$

$t = 5.7\,s$

10)



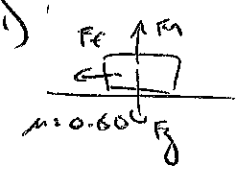

const vel

$F_n = 600\,N$

$F_f = 250\,N$

$\mu = \frac{F_f}{F_n} = \frac{250}{600} = 0.42$

11)




$F_g = mg = m(9.8) = 9.8m$

$F_n = 9.8m$

$F_f = \mu F_n = (0.60)(9.8m) = 5.9m$

$(F_f =)\ F_{net} = ma$

$5.9m = ma$

$5.9\,m/s^2 = a$

$V_f^2 = V_i^2 + 2ad$

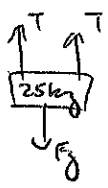
$(0)^2 = (30)^2 + 2(-5.9)d$

$0 = 900 - 11.8d$

$11.8d = 900$

$d = 76.2\,m$

12)




$F_g = mg = (25)(9.8) = 245\,N$

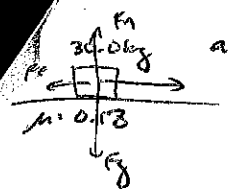
$F_{net} = ma$

$2T - F_g = ma$

$2T - 245 = (25)(0)$

$2T = 245$

$T = 122\,N$




$F_g = mg = (30.0)(9.8) = 294\,N$

$F_n = 294\,N$

$F_f = \mu F_n = (0.18)(294) = 52.9\,N$

$F_{net} = ma$

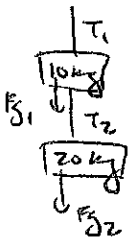
$F_a - F_f = ma$

$F_a - 52.9 = (30.0)(1.5)$

$F_a - 52.9 = 45$

$F_a = 97.9\,N$

14)





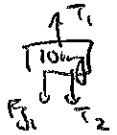
$F_{net} = ma$

$T_2 - F_{g_2} = ma$

$T_2 - (20)(9.8) = (20)(0)$

$T_2 - 196 = 0$

$T_2 = 196\,N$




$F_{net} = ma$

$T_1 - F_{g_1} - T_2 = ma$

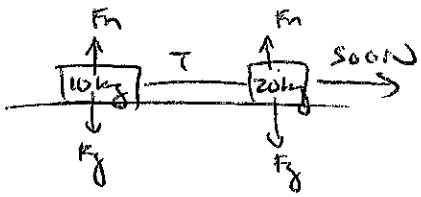
$T_1 - (10)(9.8) - (196) = (10)(0)$

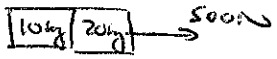
$T_1 - 98 - 196 = 0$

$T_1 - 294 = 0$

$T_1 = 294\,N$

15)

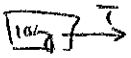



$F_{net} = ma$

$500 = (30)a$

$16.7\,m/s^2 = a$

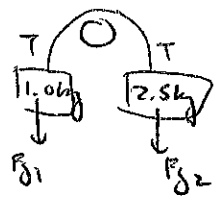



$F_{net} = ma$

$T = (10)(16.7)$

$T = 167\,N$

16)




$F_{g_1} = m_1 g = (1.0)(9.8) = 9.8\,N$

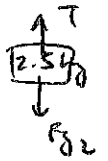
$F_{g_2} = m_2 g = (2.5)(9.8) = 24.5\,N$


$\Rightarrow 14.7\,N$

$F_{net} = ma$

$14.7 = (3.5)a$

$4.2\,m/s^2 = a$




$F_{net} = ma$

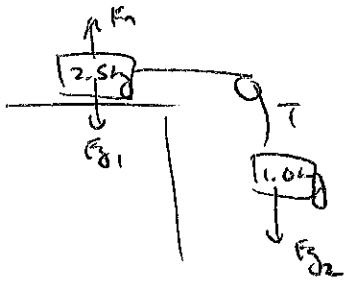
$F_{g_2} - T = m_2 a$

$(24.5) - T = (2.5)(4.2)$

$24.5 - T = 10.5$

$T = 14\,N$

b)




$F_{g_2} = m_2 g = (1.0)(9.8) = 9.8\,N$


$F_{net} = ma$

$9.8 = (3.5)a$

$2.8\,m/s^2 = a$


$F_{net} = ma$

$F_{g_2} - T = m_2 a$

$(9.8) - T = (1.0)(2.8)$

$9.8 - T = 2.8$

$T = 7.0\,N$