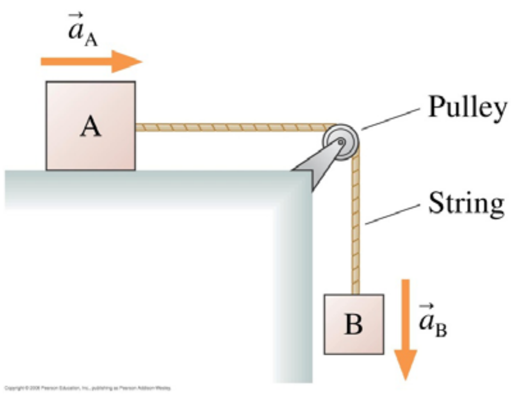
Physics 2211K
Practice for Test 2

1. In the system sketched below, block A slides on a ***frictionless surface*** and the string connecting the two blocks is ***massless***.



   a. Sketch the ***free-body diagrams for masses A and B*** showing all the forces acting on them.

   b. Write the ***F=ma*** relations for masses A and B based on the free-body diagrams of part a.

   c. If $M_B = 2\ kg$ and the tension in the string $T = 12\ N$, calculate the acceleration of the objects. $\boxed{4\ m/s^2}$

   d. If $M_B = 2\ kg$ and the tension in the string $T = 12\ N$, calculate M_A. $\boxed{3\ kg}$

2. For the system sketched above, $M_B = 4\ kg$, $M_A = 8\ kg$, $\mu_s = 0.4$, and $\mu_k = 0.2$. ($g = 10\ m/s^2$)

   a. Sketch the ***free-body diagrams for masses A and B*** showing all the forces acting on them.

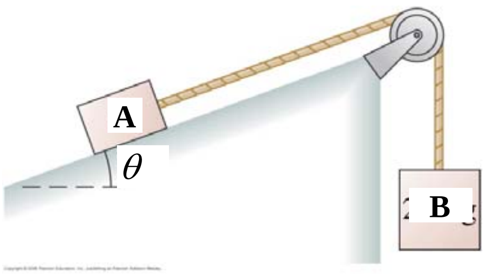
   b. Write the ***F=ma*** relations for masses A and B based on the free-body diagrams of part a.

   c. Calculate the tension in the string and the acceleration of the objects if they begin from rest. $\boxed{a = 2\ m/s^2\ ;T = 16\ N}$

   d. How would part ***c.*** be different if $\mu_s = 0.6$, and $\mu_k = 0.4$? $\boxed{a = 0\ m/s^2\ ;T = 40\ N}$

   e. Calculate how far M_B travels in ***4 s*** if it begins from rest in part ***c***. $\boxed{d = 16\ m}$

3. On the sketch below, the sloping surface is frictionless.



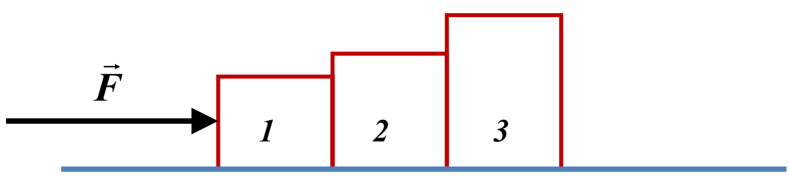
   a. Draw free-body diagrams for ***masses A and B*** showing ***all the forces*** acting on each.

   b. Use the free body diagram to write the ***F=ma*** relations for both A and B.

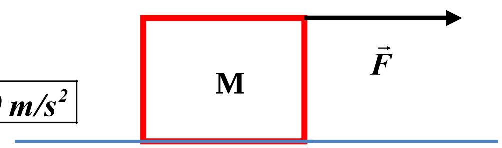
   c. If $M_A = 2M_B$, calculate the ***angle*** θ at which the ***acceleration is zero***. $\boxed{\theta = 30°}$

4. Re. the set of objects sketched below:
   a. Draw free-body diagrams for each of the masses shown (concentrate only on the horizontal forces);
   b. Use the free-body diagrams to write the ***F=ma*** relations for each mass;
   c. From the ***F=ma*** relations and Newton's 3rd law, develop expressions for the accelerations of each object;
   d. Develop an expression for the forces of contact with which each object acts on the one adjacent to it.
   e. Test your expressions for the case $F = 70\ N$, $M_1 = 2\ kg$, $M_2 = 4\ kg$, and $M_3 = 8\ kg$ by calculating the acceleration and the forces of contact.

   $a = 5\ m/s^2$; $F_{2,3} = 40\ N$; $F_{1,2} = 60\ N$



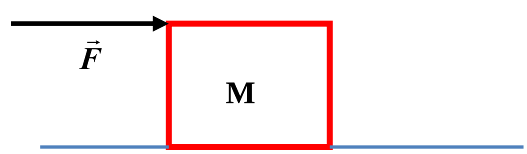
5. Re. the object sketched below:
   a. Calculate the object's acceleration from rest if the surface is frictionless, M = 12 kg, and F = 50 N. $a = 4.16\ m/s^2$
   b. Repeat ***a.)*** for the case $\mu_s = 0.5$ and $\mu_k = 0.2$. $a = 0\ m/s^2$
   c. Repeat ***a.)*** for the case $\mu_s = 0.35$ and $\mu_k = 0.1$. $a = 3.17\ m/s^2$



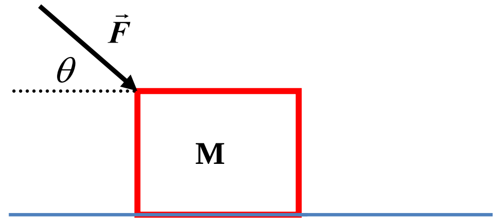
6. Re. the object sketched below:
   a. Calculate the object's acceleration from rest if the surface is frictionless, M = 12 kg, and F = 50 N. $a = 4.16\ m/s^2$
   b. Repeat ***a.)*** for the case $\mu_s = 0.5$ and $\mu_k = 0.2$.

   $a = 0\ m/s^2$

   c. Repeat ***a.)*** for the case $\mu_s = 0.35$ and $\mu_k = 0.1$. $a = 3.17\ m/s^2$



7. Re. the object sketched below:



a. Sketch the free-body diagram for the object shown showing all forces including friction;

b. Use the free-body diagram to write the ***F = ma*** relations (for horizontal & vertical directions);

c. Use the ***F=ma*** relations to calculate the object's acceleration from rest if the surface is frictionless, ***θ = 30°, M = 4 kg, and F = 50 N***. $\boxed{a = 10.8\ m/s^2}$

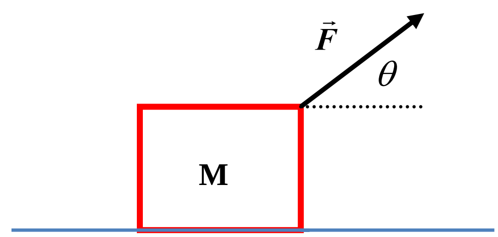
d. Repeat ***c.)*** for the case $\mu_s = 0.5$ ***and*** $\mu_k = 0.2$. $\boxed{a = 7.6\ m/s^2}$

e. Repeat ***c.)*** for the case $\mu_s = 0.35$ ***and*** $\mu_k = 0.1$. $\boxed{a = 9.33\ m/s^2}$

f. Repeat ***d.)*** for the case ***M = 8 kg***. $\boxed{a = 0\ m/s^2}$

d. Challenge question: for given values of ***θ, M, and F,*** find an expression for the largest value μ_s can have if there will be any acceleration at all.

8. Re. the object sketched below:



a. Sketch the free-body diagram for the object shown showing all forces including friction;

b. Use the free-body diagram to write the ***F = ma*** relations (for horizontal & vertical directions);

c. Use the ***F=ma*** relations to calculate the object's acceleration from rest if the surface is frictionless, ***θ = 30°, M = 4 kg, and F = 50 N***. $\boxed{a = 10.8\ m/s^2}$

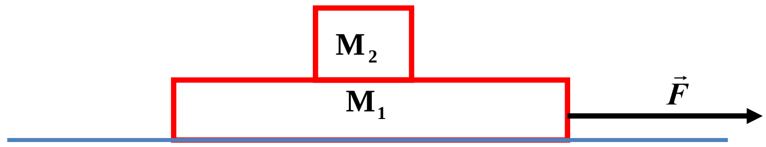
d. Repeat ***c.)*** for the case $\mu_s = 0.5$ ***and*** $\mu_k = 0.2$. $\boxed{a = 10.1\ m/s^2}$

e. Repeat ***c.)*** for the case $\mu_s = 0.35$ ***and*** $\mu_k = 0.1$. $\boxed{a = 10.5\ m/s^2}$

9. Re. the object sketched below:

   a. Sketch the free-body diagram for the object shown showing all forces including friction;

   b. Use the free-body diagram to write the $\boldsymbol{F = ma}$ relations for M_1 and M_2 (for horizontal & vertical directions);



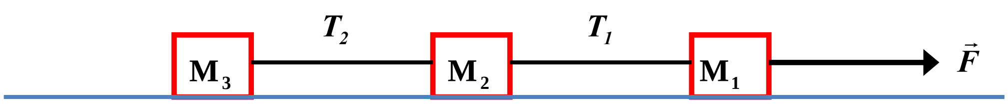
   c. For the case $M_1 = 12$ kg, $M_2 = 4$ kg, and $F = 50$ N calculate the acceleration of each object from rest if there is no friction either between M_1 and the horizontal surface or M_1 and M_2.

   $a_1 = 4.2\ m/s^2;\ a_2 = 0\ m/s^2$

   d. Repeat part ***c.)*** for the case of friction between M_1 and the horizontal surface ($\mu_s = 0.25$ ***and*** $\mu_k = 0.1$) and between M_1 and M_2 ($\mu_s = 0.5$ ***and*** $\mu_k = 0.2$). $a_1 = a_2 = 2.13\ m/s^2$

   e. Repeat part ***d.)*** for the case $F = 200$ N. $a_1 = 8\ m/s^2;\ a_2 = 2\ m/s^2$

10. Re. the object sketched below:



   a. Sketch the free-body diagram for each mass showing all forces including friction;

   b. Use the free-body diagrams to write the $\boldsymbol{F = ma}$ relations for each mass (for horizontal & vertical directions);

   c. For the case of ***no friction***, $F = 500$ N, $M_1 = 12$ kg, $M_2 = 8$ kg, ***and*** $M_3 = 10$ kg, calculate the acceleration and the tension in each string (T_1 ***and*** T_2);

   $a = 16.7\ m/s^2;\ T_1 = 300\ N;\ T_2 = 166.7\ N$

   d. Repeat ***c.)*** for the case of friction for all objects characterized by $\mu_s = 0.5$ ***and*** $\mu_k = 0.2$***;***

   $a = 14.7\ m/s^2;\ T_1 = 300\ N;\ T_2 = 166.7\ N$

   e. Repeat ***c.)*** for the case of friction for each object characterized by ($\mu_s = 0.5$ ***and*** $\mu_k = 0.2$) for M_1, ($\mu_s = 0.6$ ***and*** $\mu_k = 0.1$) for M_2, and ($\mu_s = 0.35$ ***and*** $\mu_k = 0.1$) for M_3.

   $a = 15.3\ m/s^2;\ T_1 = 292.8\ N;\ T_2 = 162.7\ N$

11. An object with ***mass = 4 kg*** is whirled in a vertical circular path using a string ***1.2 m long***.

    a. Sketch free-body diagrams for the object at the bottom of its path and at the top of the path;

    b. Write the ***F=ma*** relations for the object at the top and the bottom of its path;

    c. Use the ***F=ma*** relations to calculate the tension in the string when the object travels at $v_t = 5$ ***m/s*** at the top and bottom of its path. $\boxed{T_{top} = 43.2\ N;\ T_{bottom} = 123.2\ N}$

    d. Use the ***F=ma*** relations to find the minimum speed the object can have at the top of its path for it to remain circular. $\boxed{v_{min,\,top} = 3.46\ m/s}$

12. Mass $M_1 = 4$ ***kg*** travels at $v_1 = 20$ ***m/s*** in the ***+x*** direction and collides with $M_2 = 2$***kg*** at rest. After the collision, they stick together. ***Calculate the velocity of the combined masses after the collision.*** $\boxed{v_f = 13.3\ m/s, +x\ direction}$

13. Mass $M_1 = 4$ ***kg*** travels at $v_1 = 20$ ***m/s*** in the ***+x*** direction and collides with $M_2 = 2$***kg*** traveling at $v_2 = 30$ ***m/s*** in the ***+y*** direction. After the collision, they stick together. ***Calculate the velocity of the combined masses after the collision.*** $\boxed{\vec{v}_f = \left(13.3\,\hat{i} + 10\,\hat{j}\right) m/s}$

14. Mass $M_1 = 4$ ***kg*** travels at $v_1 = 20$ ***m/s*** in the ***+x*** direction and collides with $M_2 = 2$***kg*** traveling at $v_2 = 15$ ***m/s*** in the ***-x*** direction. After the collision, M_1 has velocity components $v_{1fx} = +15$ ***m/s*** and $v_{1fy} = -5$ ***m/s***. ***Calculate the velocity of*** M_2 ***after the collision.***

    $\boxed{\vec{v}_{2f} = \left(20\,\hat{i} + 25\,\hat{j}\right) m/s}$