Name: ____ Total Points: _______
(Last) (First)

Physics 201

Exam 2

Write also your name in the appropriate box of the scantron

Name: ____ Total Points: _______
(Last) (First)

Multiple choice questions [60 points]

Answer all of the following questions. Read each question carefully. **Fill the correct bubble on your scantron sheet**. Each correct answer is worth 4 points. Each question has exactly one correct answer.

1. You take the elevator from the first to the fourth floor. The normal force acting on you by the elevator does zero work.

A. `True`
B. `False` (W=Nd and d is the distance between the 1st and 4th floors)

2. You are standing on your skateboard. Your friend gives a gentle push to the skateboard. The friction force acting on you by the skateboard does

A. `negative work`
B. `zero work`
C `positive work` (The net force acting on you is the friction force. Your kinetic energy increases. The friction force does positive work).

3. You place a ruler on a sheet of paper on a horizontal table. You pull the sheet fast and hard enough so that the ruler slides on the paper. The friction force acting on the ruler by the paper does

A. `negative work`
B. `zero work`
C `positive work` (same as above except for the type of friction which is kinetic in this case)

4. Normal forces are always directed vertically upward.

A. `True`
B. `False` (Hold a book with your hand against a wall. The normal force exerted by the wall on the book is horizontal)

5. Gravity is a conservative force

A. `True` (Check your class notes. The work of the weight of an object is path independent).
B. `False`

Name: ____ Total Points: _______
(Last) (First)

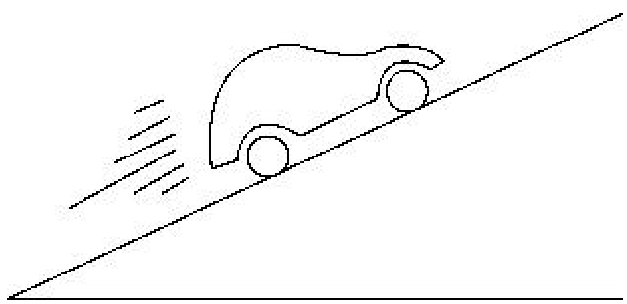
6. Kinetic friction is a conservative force

A. **True**
B. <u>**False**</u> (The longer the path, the more work is done by kinetic friction. The work done by kinetic friction is not path independent).

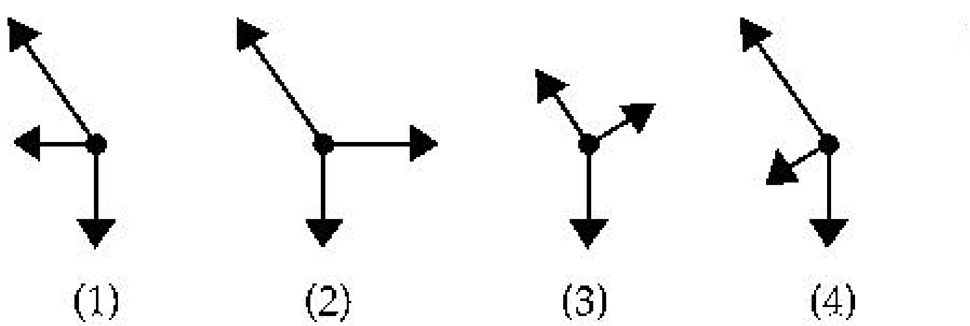
7. When a particle moves on a circle, the acceleration of the particle is always directed toward the center of the circle

A. **True**
B. <u>**False**</u> (The acceleration is directed toward the center only if the particle moves a constant speed).

8.



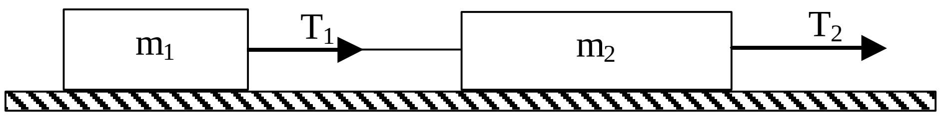
Which of the following free-body diagrams represents the car going uphill at a constant speed?



A. **(1)**
B. **(2)**
C. <u>**(3)**</u> (all the other FBD give a non zero net force)
D. **(4)**

Name: ____ Total Points: _______
(Last) (First)

9. Two masses m_1 and m_2, connected by a massless string, are accelerating uniformly on a frictionless surface as shown. What is the ratio of the tensions T_1/T_2?

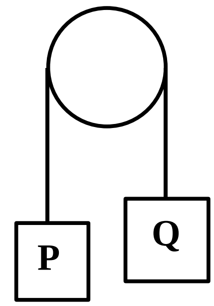


A. m_1/m_2
B. m_2/m_1
C. $(m_1 + m_2)/m_1$
D. <u>$m_1/(m_1 + m_2)$</u>
Mass m_1: $T_1 = m_1 a$
Mass m_1+m_2: $T_2 = (m_1+m_2)a$
E. $m_2/(m_1 + m_2)$

Name: ____ Total Points: _______
(Last) (First)

Questions 10 through 15 all refer to the same problem.

Blocks P and Q are connected by a massless, inextensible string that runs over a frictionless peg. The masses of block P and Q are M_P and M_Q. M_P is less than M_Q.



10 The magnitude of the net force on block P is

- **A.** less than $M_P g$
- **B.** equal to $M_P g$
- **C.** greater than $M_P g$ but less than $M_Q g$
- **D.** equal to $M_Q g$
- **E.** greater than $M_Q g$

$|\vec{a}_P| = |\vec{a}_Q|$ since P and Q are connected by an inextensible string. Since $M_P<M_Q$, $\vec{a}_P$ is directed up, $\vec{a}_Q$ is directed down. Q doesn't fall as fast as it would in a free fall. Thus, its acceleration is less than g. The magnitude of the net force acting on P is thus
$M_P|\vec{a}_p| < M_P g$ M

At time t_1, block P is moving down with speed v_1=4cm/s. At time $t_2>t_1$, it has speed v_2=2cm/s directed down. Between t_1 and t_2, block P moves 10 cm down. Questions 11 through 15 refer to this time interval.

11 The sign of the net work done on block P is

- **A.** positive
- **B.** negative (since the change of kinetic energy of P is negative)
- **C.** zero

12 The sign of the work done on block P by the string is

- **A.** positive
- **B.** negative (the tension is up, the displacement is down)
- **C.** zero

13 Compare the absolute value of the work done on block P by the string ($|W_{PS}|$) to the absolute value of the work done on block P by the Earth ($|W_{PE}|$)

- **A.** $|W_{PS}|$ is greater than $|W_{PE}|$ ($W_{net}=W_{PE}+W_{PS}<0$ (from 11), $W_{PS}<0$ (from 12), and since the weight and the displacement are both down, $W_{PE}>0$)
- **B.** $|W_{PS}|$ is less than $|W_{PE}|$

C. $|W_{PS}|$ is equal to $|W_{PE}|$

14 The sign of the work done on block Q by the string (W_{QS}) is

A. positive (tension is up, displacement is up)
B. negative
C. zero

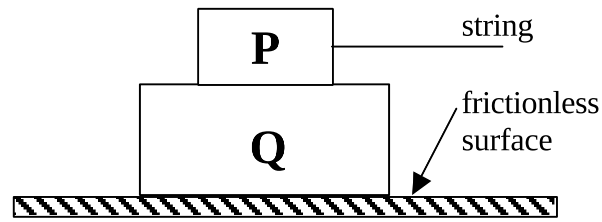
15 Compare the absolute value of the work done on block P by the string ($|W_{PS}|$) to the absolute value of the work done on block Q by the string ($|W_{QS}|$).

A. $|W_{PS}|$ is greater than $|W_{QS}|$
B. $|W_{PS}|$ is less than $|W_{QS}|$
C. $|W_{PS}|$ is equal to $|W_{QS}|$ (same magnitude for the forces acting on P and Q by the string, same magnitude for the displacement of P and Q)

Name: ____ Total Points: _______
(Last) (First)

PROBLEM [40 points]

A string pulls on block P, which is on top of block Q. Block Q has mass m_Q and block P has mass m_P. The coefficients of friction between P and Q are μ_s(static) and μ_k(kinetic). The acceleration of gravity is g. Neglect friction between block Q and the table.



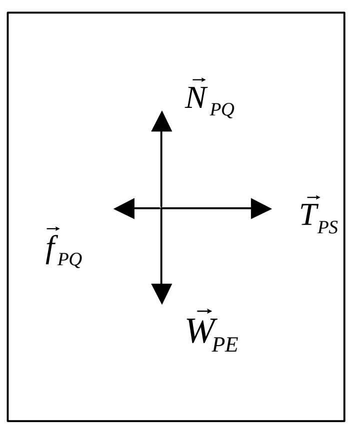
For questions 1-4 assume that block P does not slip on block Q.

1). [3 pts] In the spaces provided, indicate the directions of the velocities, accelerations, and net forces of each block. If any of these is zero, state so explicitly. (The velocity of P is given.)

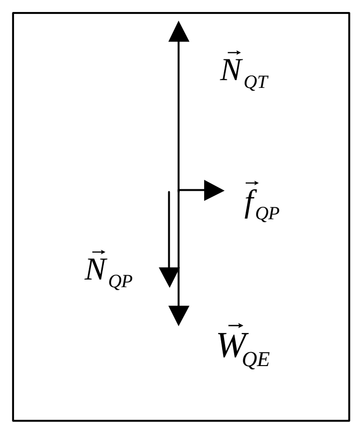
	v	a	F_{net}
P	→	→	→
Q	→	→	→

2). [10 pts] Draw free-body diagrams for blocks P and Q. Label each arrow to indicate: the type of force, the object the force is exerted on, and the object the force is exerted by.

Block P



Block Q



3). [8 pts] Write an expression for the maximum acceleration of block P if it does not slip on block Q. Your expression should only use quantities taken from this list: m_P, m_Q, g, μ_s and μ_k

For Q: $f_{QP} = m_Q a_Q$

P and Q have the same acceleration: $a_P = a_Q$. It is maximum when f_{QP} is maximum, i.e. $f_{QP} = f_{PQ} = \mu_s N_{PQ} = \mu_s m_P g$

Thus, $a_P = a_Q = \mu_s m_P g / m_Q$

Name: ____ Total Points: _______
(Last) (First)

4). [8 pts] Write an expression for the maximum tension in the string if block P does not slip on block Q. Your expression should only use quantities taken from this list: m_P, m_Q, g, μ_s and μ_k

From the FBD for P:
$T_{PS} = f_{PQ} + m_P a_P$

$$T_{PS} = (\frac{m_P^2}{m_Q} + m_P) m_s g$$

For questions 5 and 6, assume that the force exerted by the string, T_{PS}, is sufficiently large that block P begins to slip on block Q.

5). [3 pts] Indicate the directions of the velocities, accelerations, and net forces of each block a short time after block P starts to slip. If any of these is zero, state so explicitly. (The velocity of P is given.)

	v	a	F_{net}
P	→	→	→
Q	→	→	→

6). [8 pts] Write an expression for the acceleration of block P. Your expression should only use quantities taken from this list: T_{PS}, m_P, m_Q, g, μ_s and μ_k

Using a FBD for P:

$T_{PS} = f_{PQ} + m_P a_P$

f_{PO} is a kinetic friction force.

$$a_P = \frac{T_{PS}}{m_P} - m_k g$$