Name: ____ Total Points: _______
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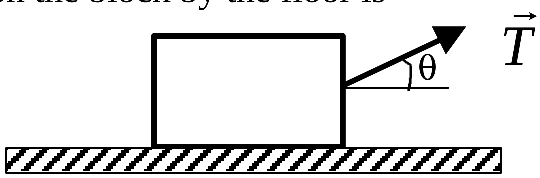
Multiple choice questions

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

1. You are standing on a bus stopped at a red light. The light turns green and the bus start accelerating. The work done by the friction force acting on you by the floor of the bus is

A. positive
Force and displacement have the same direction
B. negative
C. 0
D. Can't tell without knowing the acceleration

2. A block of mass m is pulled along a rough horizontal floor by an applied force $\vec{T}$ as shown. The vertical component of the force exerted on the block by the floor is



A. **mg**
B **mg-Tcosθ**
C. **mg+Tcosθ**
D. **mg-Tsinθ**
Since
$\vec{N}_{BT} + \vec{W}_{BE} + \vec{T} = m\vec{a}$
Along the vertical
$N_{BT} - mg + T\sin q = 0$
E. **mg+Tsinθ**

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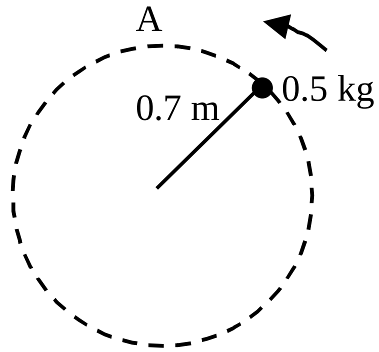
3. The 0.5 kg iron ball shown is being swung in a vertical circle at the end of a 0.7 m long string. How slowly can the ball go through its top position (point A) without having the string go slack? ($g=9.8\ m/s^2$)



A. 1.3 m/s

B. 2.6 m/s

In the limit, the tension in the string is 0 at the top of the circle. Thus,

$$mg = m\frac{v^2}{r} \Rightarrow v = \sqrt{gr}$$

C. 3.9 m/s

D. 6.9 m/s

E. 9.8 m/s

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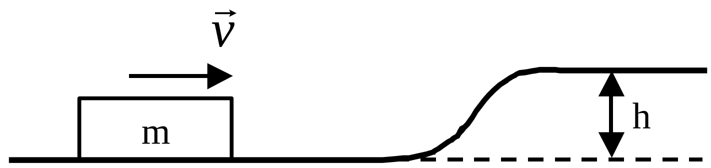
4. For a block of mass m to slide without friction up the rise of height h shown, it must have a minimum initial speed of



A. $\frac{1}{2}\sqrt{gh}$

B. $\sqrt{\frac{gh}{2}}$

$\sqrt{2gh}$

C. For the minimum initial speed, the block comes to rest at the top of the incline. Use the work energy theorem

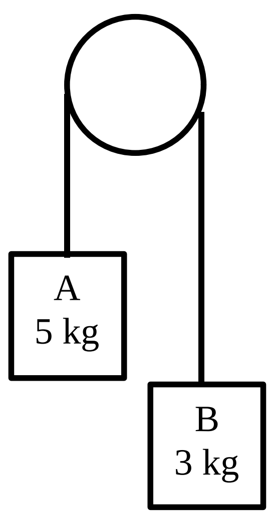
$0-\frac{1}{2}mv^2=-mgh \Rightarrow v=\sqrt{2gh}$

D. $2\sqrt{2gh}$

E. $2\sqrt{gh}$

Questions 5 through 9 all refer to the same problem.

Two masses A (5kg) and B(3kg) are connected by a massless inextensible string passing over a frictionless pulley as shown. At t=0s, you observe that block A is moving up.



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5. What is the direction of the acceleration of block A?

A. up

B. down

Since A is heavier than B, the acceleration of A is directed down.

C. undefined since $\vec{a}_A = 0$

6. How does the magnitude of the acceleration of block A compare with the magnitude of the acceleration of block B?

A. $|\vec{a}_A| > |\vec{a}_B|$

B. $|\vec{a}_A| < |\vec{a}_B|$

C. $|\vec{a}_A| = |\vec{a}_B|$

Since the string is inextensible and remains tight, A and B have the same motion along the vertical at all times. The only difference is that when B moves up, A moves down and vice versa.

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7. How does the magnitude of the tension acting on A by the string compare with the magnitude of the tension acting on B by the string?

A. $\left|\vec{T}_{AS}\right| > \left|\vec{T}_{BS}\right|$

B. $\left|\vec{T}_{AS}\right| < \left|\vec{T}_{BS}\right|$

C. $\left|\vec{T}_{AS}\right| = \left|\vec{T}_{BS}\right|$

since the pulley is frictionless and the string is inextensible and massless (recall the tension tutorial)

8. How does the magnitude of the net force acting on A compare with the magnitude of the net force acting on B?

A. $\left|\vec{F}_{net}^{A}\right| > \left|\vec{F}_{net}^{B}\right|$

$F_{net} = m\vec{a}$

A and B have the same acceleration and $m_A > m_B$

B. $\left|\vec{F}_{net}^{A}\right| < \left|\vec{F}_{net}^{B}\right|$

C. $\left|\vec{F}_{net}^{A}\right| = \left|\vec{F}_{net}^{B}\right|$

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9. Between t=0s and t=2s, how does the change of kinetic energy of block A compare with the change of kinetic energy of block B?

Bad question! Everyone got a point for this question:

At any time, the velocities of A and B have the same magnitude. Thus

$$v_{f\,A}^2 - v_{i\,A}^2 = v_{f\,B}^2 - v_{i\,B}^2 \Rightarrow \Delta KE_A = \frac{m_A}{m_B}\Delta KE_B = \frac{5}{3}\Delta KE_B$$

But we don't have enough information to know the sign of ΔKE_A and ΔKE_B. Any of the answers below could be correct.

A. $\Delta KE_A = \Delta KE_B$

B. $\Delta KE_A = -\Delta KE_B$

C. $\Delta KE_A < \Delta KE_B$

D. $\Delta KE_A > \Delta KE_B$

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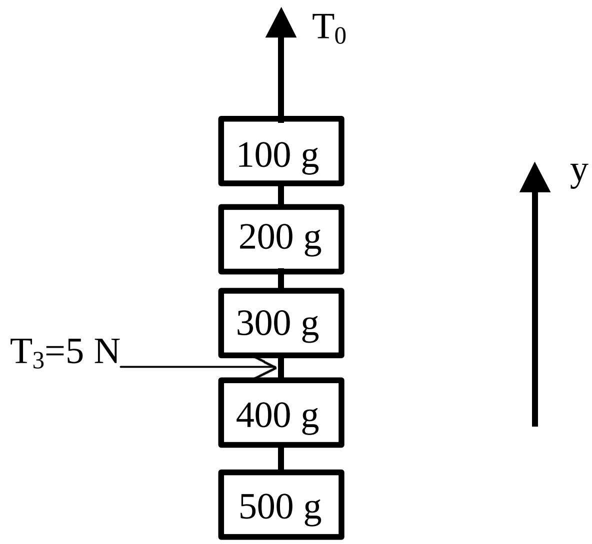
Questions 10 through 14 all refer to the same problem.

Five masses are connected by massless inextensible links to form a vertical chain as shown. The chain starts moving at t=0 from rest. The tension in link 3 is observed to be 5 N. Take g=9.8 m/s^2.



10. Find the acceleration of the chain (as indicated by the y axis, the positive direction is up).
For the system made of the 400g and 500g masses:
along the vertical

$$T_3 - (0.4+0.5)g = (0.4+0.5)a \Rightarrow a = -9.8 + \frac{5}{0.9} = 4.24 m/s^2$$

A. 12.5 m/s^2
B. 5.6 m/s^2
C. -4.2 m/s^2
For the system made of the 400g and 500g masses:
Apply Newton's second law (along y)

$$T_3 - (0.4+0.5)g = (0.4+0.5)a \Rightarrow a = -9.8 + \frac{5}{0.9} = -4.24 m/s^2$$

D. -8.3 m/s^2
E. -9.8 m/s^2

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11. Find the magnitude of the tension T_0 at the top of the chain

A. 0 N
B. 6 N
C. 8.3 N
For the system made of all 5 masses
$T_0 - (0.1+0.2+0.3+0.4+0.5)g = (0.1+0.2+0.3+0.4+0.5)a$
$\Rightarrow T_0 = 1.5\times 9.8 + 1.5\times(-4.24) = 8.33N$
D. 12.4 N
E. 14.7 N

12. What is the sign of the work done by T_0 on the system made of the 5 masses and links when the system is moving?

A. positive
B. negative
The acceleration is directed down and the system of the 5 masses starts from rest. Thus the system is moving down.
Since T_0 is up and the displacement is down, the work done by T_0 is negative.

C. 0

13. Find the magnitude of the net force acting on the system made of the 5 masses and links

A. 2.3 N
B. 6.4 N
The net force is $\vec{F}_{net} = 1.5\times\vec{a} = 1.5\times(-4.24)\hat{y} = -6.37\hat{y}$

C. 8.7 N
D. 9.3 N
E. 14.7 N

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14. The third link between the 300 g and 400 g masses suddenly breaks. After the 3rd link breaks, what is magnitude of the tension acting on the 500g mass by the 4th link between the 500 g and 400 g masses?

A. 0 N
The two masses are now free falling. The acceleration of each mass is g. For each mass, the net force is equal to the weight. The tension by the string on the 500g mass must be 0.

B. 0.9 N

C. 4.9 N

D. 8.8 N

E. 12.4 N

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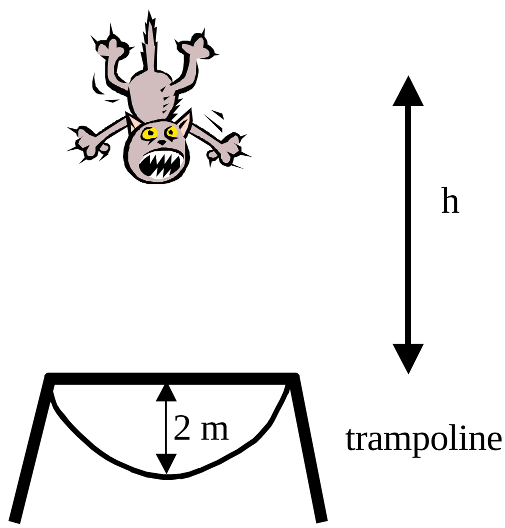
Questions 15 through 18 all refer to the same problem.

A 5kg cat falls off a roof located a height h above a trampoline. The cat lands on the trampoline. The trampoline deflects 2 m before bringing the cat to a temporarily halt. The spring constant of the trampoline is k=125 N/m. Take g=9.8 m/s^2.



15. When the cat comes momentarily to rest, how much work has been done by the force on the cat by the trampoline?

The work done by the spring is given by

$$W = -\frac{1}{2}k(x_f^2 - x_i^2) = -\frac{1}{2}\times 125 \times (2^2 - 0^2) = -250J$$

A. -500 J
B. -250 J
C. 0 J
D. 250 J
E. 500 J

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16. What is the sign of the net work done on the cat during the entire fall (from the point where the cat falls off the roof to the point where the cat comes momentarily to rest).

A. positive
B. negative
C. 0
Apply the work energy theorem (initial and final velocities are 0)

$$\Delta KE = W = 0$$

17. What is the maximum magnitude of the acceleration experienced by the cat?

A. 9.8 m/s^2
B. 19.6 m/s^2
C. 31.4 m/s^2
D. 40.2 m/s^2
When the cat is falling the magnitude of the acceleration is 9.8m/s^2
When the cat is in contact with the trampoline the acceleration is such that (positive direction is down)

$$-kx + mg = ma \Rightarrow a = g - \frac{kx}{m}$$

The magnitude is maximum for x=2m

$$a = 9.8 - \frac{125 \times 2}{5} = -40.2 m/s^2$$

E. 59.8 m/s^2

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18. What is the height h?

A. 2.1 m
B. 3.1 m
Using the work energy theorem from the start of the fall to the end of the fall (when the cat is temporarily at rest)

$$\Delta KE = 0 = W_{net} = mg(h + x_f) - \frac{1}{2}k(x_f^2) \Rightarrow h = 3.1m$$

C. 5.1 m
D. 7.1 m
E. 10 m