Q3 Solutions

Monday, July 11, 2022 8:04 AM

Name:_____ ID:_____

Physics 201

Quiz 3

7/11/2022

Collaboration is not allowed. Allowed on your desk are: three 8.5 x 11 inch doubled sided sheets of notes, non-communicating graphing scientific calculator, scratch paper, writing utensils, and the exam. You will have 50 minutes to complete this quiz.

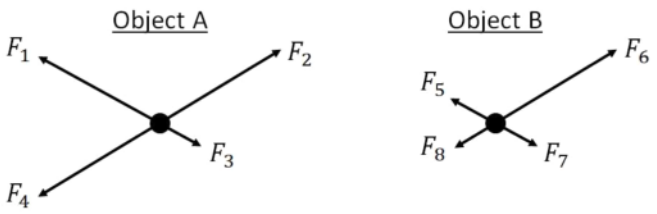
For question 1 **fill in the square** next to all correct answers. A given problem may have more than one correct answer. Each correctly bubbled answer will receive two points. There are **5** correct answers in this section and only the first **5** filled in answers will be graded. There is no partial credit.

1. Which of the following statements must be true?

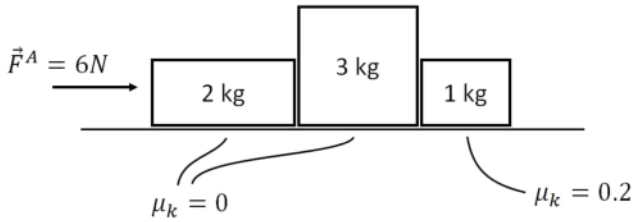
   - ☐ (a) Momentum is conserved for every system
   - ☐ (b) The force of gravity on an object near Earth's surface is g
   - ☑ (c) Momentum is a vector
   - ☐ (d) Impulse is a scalar
   - ☑ (e) The total momentum in the universe is conserved
   - ☐ (f) If an object is in uniform circular motion, its acceleration is constant
   - ☐ (g) If an object is uniform circular motion, its momentum is constant
   - ☑ (h) If an object is in uniform circular motion, its frequency is constant

2. Which of the following pairs of forces could possibly be third law force pairs? (the force types are unknown, but none of the forces are tension forces)

   - ☐ (a) F_1 and F_3
   - ☐ (b) F_2 and F_4
   - ☐ (c) F_2 and F_6
   - ☑ (d) F_4 and F_6
   - ☐ (e) F_3 and F_7
   - ☑ (f) F_3 and F_5
   - ☐ (g) F_5 and F_7



3. (8 points) Three blocks are on a table at rest, in contact with each other, as shown. A force is applied to the left block in the positive x direction. The two blocks on the left have no friction with the table, but the right-most block has a coefficient of kinetic friction of 0.2 with the table. Assume that the applied force is large enough to overcome the initial static friction.



(a) How do the accelerations of the blocks compare to each other? (is one larger? which one? etc) Explain using any combination of words, algebra, diagrams, etc.

all accelerations are equal b/c they are being pushed together ⇒ move together

(b) Find the acceleration of the 1 kg block.

treat as one system

$\Sigma f = ma$ ← all 3 blocks need to be accelerated

$+6N - (0.2)(1kg)(9.8 m/s^2) = (2+3+1)\,a$

$a = 0.673\ m/s^2$

$f^f \longleftarrow\!\bullet\!\longrightarrow F^A = 6N$

$f^f = \mu mg$

1 kg b/c only that block has μ

(c) Find the magnitude of the normal force from the 2 kg block acting on the 3 kg block.

2kg block

$\Sigma f = ma$

$+6N + F_{32}^N = (2kg)(0.673\ m/s^2)$

$F_{32}^N \longleftarrow\!\bullet\!\longrightarrow F^A$

$F_{32}^N = -4.65\ N \Rightarrow \boxed{|F_{23}^N| = 4.65\ N}$

switch of indices!

b/c this is a third law force pair with F_{23}^N

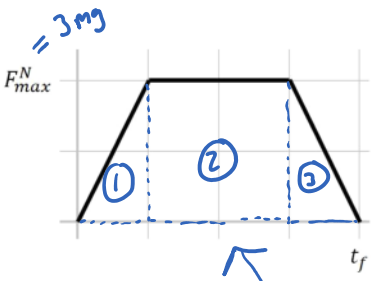
⇒ magnitudes are the same

$|F_{23}^N| = |F_{32}^N| = 0.224N$

(d) Find the magnitude of the normal force from the 3 kg block acting on the 2 kg block.

$|F_{23}^N| = |F_{32}^N| = 4.65\ N$

4. (10 points) A cat of mass m falls a distance h and comes to rest comfortably on its feet in an amount of time, t_f. On impact with the ground, the normal force of the ground acting on the cat is recorded using a force sensor. The force is shown in the graph. The maximum normal force (labeled on the graph) is three times the weight of the cat.



finding area under curve

① & ③ $\Rightarrow \left(\frac{1}{4} t_f\right)\left(F^N_{max}\right)\left(\frac{1}{2}\right)$

② $\Rightarrow \left(\frac{1}{2} t_f\right)\left(F^N_{max}\right)$

$\Rightarrow$ total area $= \frac{3}{4} t_f F^N_{max}$

(a) Find a symbolic solution for the velocity of the cat just before it hits the ground. Your solution should be in terms of g, and h. Your solution should not include the mass, m.

$a = -g$

$v_{fy}^2 = v_{iy}^{2\,=0} + 2 a_y \Delta y$ $\quad \begin{cases} \Delta y = -h \\ a_y = -g \end{cases}$

$v_{fy}^2 = 2gh$

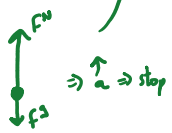
$v_{fy} = \sqrt{2gh}$

(b) Find a symbolic solution for the amount of time, t_f, (labeled on the diagram) over which the collision occurs in terms of h and g. (note: the mass, m, should not appear in your solution!)

$\Delta \vec{p} = m \Delta \vec{v} = m \vec{v}_f - m \vec{v}_i^{\,=0} = m\sqrt{2gh}\ \hat{y}$

$\Delta \vec{p} = \sum f_{ext} \Delta t = (+F^N - mg)\Delta t = F^N \Delta t - mg \Delta t$

Collision



area under curve

$\Rightarrow \frac{3}{4} F^N_{max} t_f - mg t_f = m\sqrt{2gh}$

$t_f \left(\frac{3}{4} 3\cancel{m}g - \cancel{m}g\right) = \cancel{m}\sqrt{2gh}$

$t_f\, g \left(\frac{9}{4} - 1\right) = \sqrt{2gh}$

$t_f = \frac{4}{5g}\sqrt{2gh}$

$t_f = \sqrt{\frac{32h}{25g}}$

(c) If the distance that the cat falls increases, what does your symbolic solution say would happen to the collision time t_f? (does it increase? decrease? stay the same?) Explain or show using algebra or proportional reasoning. If the distance the cat falls increases, what would you expect (using your physics intuition) to happen to the collision time, assuming the maximum force stays the same? Explain. Do these two statements agree with each other? (it's ok if they don't!)

① $t_f = \sqrt{\frac{32h}{25g}}$ $\Rightarrow$ if h increases, t_f will increase

② I would expect that if the cat falls further, it will reach larger v_f $\Rightarrow$ more impulse needed to stop it $\Rightarrow$ larger Δt if F^N stays the same

these two statements agree!!