

Fall 2007

Please write your **CID** _____

Physics 105 Exam 1

Hess & Colton

3 hour time limit.

Constants: $g = 9.80 \text{ m/s}^2$

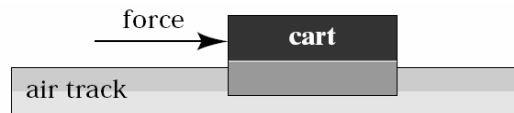
Keep four significant digits throughout your calculations; do not round up to less than four. When data is given, assume it has at least four significant digits. For example “15 meters” means 15.00 meters.

The problems are labeled with a question mark in brackets; [1?] means the answer goes in bubble sheet #1.

You are **encouraged to write your work and full answers on the exam pages** (but of course also record your final answers on the bubble sheet).

Make sure your calculator is in DEGREES, not radians.

→Write your CID above upper right corner. Did you do this _____? You won't get your exam back without writing your CID.

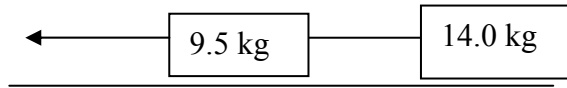


A constant force is exerted for a short length of time on a cart that is initially at rest on an air track. This force gives the cart a certain final speed. The same force is exerted for the same length of time on another cart, also initially at rest, that has four times the mass of the first one. The final speed of the heavier cart is [1?] _____ 1) one-fourth 2) four times 3) half 4) double 5) the same as that of the lighter cart.

1. if $m_2 = 4m_1$, then $a_2 = \frac{1}{4} a_1$. So $\frac{1}{4}$ the acceleration, acting over the same time, will give $\frac{1}{4}$ the final velocity (because $v = v_0 + at$).

If instead you replace the phrase “length of time” by “**distance**”, the final speed of the heavier cart is [2?] _____ 1) one-fourth 2) four times 3) half 4) double 5) the same as that of the lighter cart.

2. a_2 is still $\frac{1}{4} a_1$. But because velocity depends on the square root of distance ($v^2 = v_0^2 + 2a(x - x_0)$, and $v_0 = 0$), this means the final speed will now be half. Or you can simply try it with any numbers you make up!



What is the tension in the rope connecting the two boxes if the tension in the rope pulling the group to the left is 75 N? (There is no friction.) [3?] _____ (a) less than 38.4 N (b) 38.4 – 41.4 (c) 41.4 - 44.4 N (d) 44.4-47.4 (e) 47.4 – 50.4 (f) more than 50.4 N.

3. sum of forces on system = mass of system × acceleration of system → $a = 75\text{N} / (23.5\text{ kg}) = 3.1915\text{ m/s}^2$. Then, looking e.g. at the 14 kg box, sum of forces = $ma \rightarrow T = 14.0\text{ kg} \times 3.1915\text{ m/s}^2 = 44.681\text{ N}$.

You are a passenger in a car and not wearing your seat belt. Without increasing or decreasing its speed, the car makes a sharp left turn, and you find yourself colliding with the right-hand door. Which is the correct analysis of the situation according to Newton’s laws? [4?] _____

- 1) Before and after the collision with the door, there is a rightward force pushing you into the door.
- 2) Starting at the time of collision with the door, the door exerts a leftward force on you.
- 3) Both of the above
- 4) Neither of the above

4. (1) is not true. Your inertia keeps you moving in a straight line, but no force pushes you into the door. (2) is true. The force of the door prevents you from moving in a straight line. Therefore the answer is (2)

A car can go from 0 to 60 mph (26.82 m/s) in 8.11 seconds. If the car has a mass of 1318 kg, with what force is it pushing backwards on the road during this time? (assume no air friction) [5?] _____ (a) less than 3600 N (b) 3600 – 3900 (c) 3900 – 4200 (d) 4200 – 4500 (e) 4500-4800 (f) more than 4800 N.

5. $a = \Delta v / \Delta t = 26.82\text{m/s} / 8.11\text{s} = 3.3070\text{ m/s}^2$. By Newton 2, then, the force to produce this acceleration must be $F = ma = 1318\text{ kg} \times 3.3070 = 4358.7\text{ N}$.

Consider a horse pulling a buggy at constant velocity. The following are pairs of forces.

- I. The horse pulling on the buggy, and the buggy pulling back on the horse.
- II. The horse pulling on the buggy, and the ground pushing the horse forward.
- III. The horse pushing down on the ground, and the ground pushing up on the horse.
- IV. Gravity pulling down on the horse, and the ground pushing up on the horse.
- V. Gravity pulling down on the horse, and the horse pulling up on the Earth.

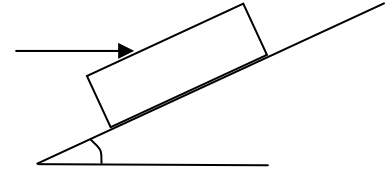
Which of the force pairs constitute ones that **must always** be equal and opposite according to Newton’s 3rd Law? [6?] _____

- | | |
|------------------|--------------------------|
| 1) I only | 6) I, III, IV, and V |
| 2) I and II | 7) III and IV only |
| 3) I and III | 8) III and V only |
| 4) I, III, and V | 9) I, II, III, IV, and V |
| 5) I, IV, and V | |



6. The Newton 3rd Law “partner forces” must be forces of the second object acting back on the first object. The only ones that are in this category are I, III, and V.

A horizontal force of 27.0 N is applied to a 3.5 kg block that is on a 33° slope as shown. There is no friction. What is the normal force? [7?] _____
 (a) less than 44 N (b) 44 - 45 N (c) 45 - 46 N (d) 46 - 47 N (e) 47 - 48 N
 (f) 49 - 50 N (g) 50 - 51 N (h) more than 51 N.



7. After drawing forces on picture and dividing the relevant ones up into components, you find that the forces in the “y”-direction are: N going up, $mg\cos\theta$ going down, and $27N \sin\theta$ going down. Then Newton 2 says: $\text{sum of forces} = ma = 0 \rightarrow T - mg\cos\theta - 27N \sin\theta = 0 \rightarrow T = 43.47 N$

A weightlifter is holding a barbell at rest on a large scale, and a first reading of the scale is taken. The weightlifter begins to lift the barbell, initially accelerating it upward from rest, and ends up holding it motionless above his head. The scale always reads a force that is [8?] _____
 1) the weight of the barbells
 2) the weight of the man
 3) the combined weight of the barbells and the man
 4) the normal force on the man. During the process, the reading on the scale will [9?] _____
 1) always be the same as the first reading
 2) be more than, then less than, then the same as the first reading
 3) be less than, then more than, then the same as the first reading
 4) always be more than the first reading

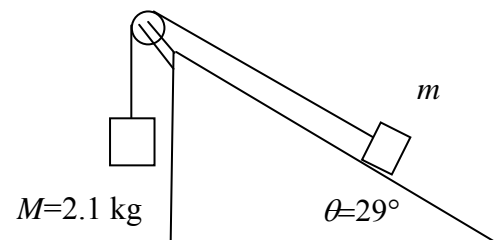
8. The scale always reads the normal force on the man. This may or may not be equal to the weight of the barbells and/or weight of man. (If they were all in an elevator accelerating upwards, for example, the scale would read heavier than the combined weight.) Thus, the best answer is (4).

9. As the man lifts up the barbell, he exerts an upward force on it, which is greater than the barbell’s weight (otherwise it wouldn’t accelerate upwards). Thus, by Newton 3, it must be exerting an equal downward force on the man. Since the man isn’t accelerating through the floor, the scale has to push up harder, so the normal force increases.

As the barbell comes to rest (decelerates) above his head, the same situation happens in reverse: the man’s force on the barbell is now less than its weight, so the barbell’s force on the man is also less than the barbell’s weight. Then since the man isn’t accelerating, the normal force drops so that the sum of forces is still zero.

You can test it out on your bathroom scale (if it responds fast enough), using a sack of potatoes (or anything heavy) in place of the barbell. Answer is (2).

If there is no friction, how large does m need to be in order for it not to be pulled up the ramp? [10?] _____ kg. (a) less than 3.8 kg (b) 3.8 - 4.1 (c) 4.1 - 4.4 (d) 4.4 - 4.7 (e) 4.7 - 5.0 (f) more than 5.0 kg.



10. Draw the forces, divide into components as usual. Looking at the forces that cause the system to accelerate, we find a force of $mg\sin\theta$ pulling in one direction and a force of Mg pulling the other. If $mg\sin\theta$ is bigger than Mg , then m will not be pulled upwards. $mg\sin\theta > Mg \rightarrow m > M/\sin\theta$, or $m > 4.332 \text{ kg}$.

If there is friction, with $\mu_s = 0.2$ and $\mu_k = 0.1$, how small can m be and still not be pulled up the ramp? [11?] _____ (a) 2.7 – 2.9 kg (b) 2.9 – 3.1 (c) 3.1 – 3.3 (d) 3.3 – 3.5 (e) 3.5 – 3.7 (f) more than 3.7 kg.

11. Now there's an extra force opposing the motion, friction $f = \mu N$. So the equation is m will not be pulled upwards if $mg\sin\theta + \mu N > Mg$. Looking at the y-components of the mass on a ramp, we find that $N = mg\cos\theta$. So, plugging that in to the first equation, $mg\sin\theta + \mu mg\cos\theta > Mg$, or $m > M/(\sin\theta + \mu\cos\theta)$, or $m > 3.183$ kg. Comment: this is less than the answer to the previous problem, so that makes sense.

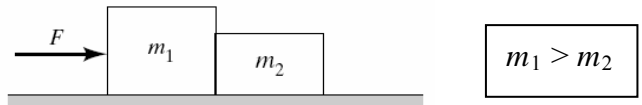
You have a hanging spring with $k = 14$ N/m. You add a 1.5 kg mass to the spring and let the spring slowly stretch out so that the mass hangs without moving. What is the force the spring is applying to the mass? [12?] _____ N. (a) 14.2 – 14.4 N (b) 14.4 – 14.6 (c) 14.6 – 14.8 (d) 14.8 – 15.0 (e) 15.0 – 15.2 (f) more than 15.2 N.

Now you give the mass a quick push downward, so that it travels 0.22 m further down before stopping and turning around. What was the force the spring was applying to the mass, at its lowest point? [13?] _____ (a) 9 – 11 N (b) 11 – 13 (c) 13 – 15 (d) 15 – 17 (e) 17 – 19 (f) 19 – 21 (g) 21 – 23 (h) 23 – 25 (i) more than 25 N.

12. If mass is motionless, the forces must sum to zero: $F_{\text{spring}} - mg = 0$. So $F_{\text{spring}} = mg = 14.7$ N

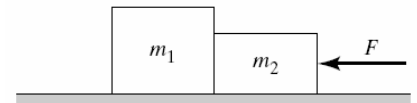
13. You need to know the total amount the spring has stretched from equilibrium, so first find the amount it stretched before the additional 0.22 m: $kx = 14.7$ N (from problem 12); $x = 1.05$ m. So the total stretch was 1.05 m + 0.22 m = 1.27 m. Then, using that stretch along with $F_{\text{spring}} = kx$, $F_{\text{spring}} = 17.78$ N.

Two blocks ($m_1 > m_2$) sitting on a frictionless table are pushed from the left by a horizontal force, as shown. They accelerate to the right. How does the magnitude of the force of m_1 on m_2 compare with the magnitude of the force of m_2 on m_1 ? [14?] _____ 1) the force of m_1 on m_2 is larger 2) the force of m_2 on m_1 is larger 3) they are equal.



14. Newton's 3rd Law: the forces are equal and opposite. Doesn't matter what the masses are, or what the accelerations are. Choice (3) is correct.

How does the magnitude of the force of m_1 on m_2 compare between the two pictures shown (the same force F pushing on the left vs. pushing on the right)? [15?] _____ 1) It is larger when F is pushing on m_1 , from the left. 2) It is larger when F is pushing on m_2 , from the right. 3) It is the same for both situations.



15. First notice that the accelerations in the two pictures are the same, because the total force is the same and the total mass is the same. The force of m_1 on m_2 in picture 1 must accelerate m_2 (it's the only force on it), so its magnitude is $m_2 \times a$. The force of m_1 on m_2 in picture 2 is the same as the force of m_2 on m_1 (by Newton 3), which is the only force on m_1 , so its magnitude is $m_1 \times a$. Since $m_1 > m_2$, the force of m_1 on m_2 is largest for picture 2. Choice (2) is correct

A car of mass 700 kg going 12 m/s goes up a hill that is 4 m high, and at the same time the engine does 50000 J of work to help the car up the hill. The car's speed at the top of the hill is [16?] _____ (a) 14 – 14.5 m/s (b) 14.5 – 15 (c) 15 – 15.5 (d) 15.5 – 16 (e) 16 – 16.5 (f) 16.5 – 17 (g) 17 – 17.5 (h) 17.5 – 18 (i) more than 18 m/s.

16. I'll put $y = 0$ at the bottom of the hill

$$KE_i + W_{in} = KE_f + PE_f$$

$$\frac{1}{2}mv_i^2 + W_{in} = \frac{1}{2}mv_f^2 + mgh \quad v_f^2 = v_i^2 + \frac{2W_{in}}{m} - 2gh$$

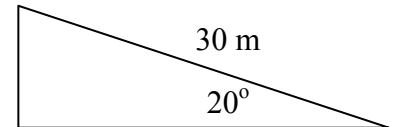
$$v_f = \sqrt{12^2 + 2 \cdot 50000 / 700 - 2 \cdot 9.8 \cdot 4}; = 14.43 \text{ m/s}$$

Three skaters approach a drop-off going the same speed. One simply goes forward off the edge into the air (like a projectile), one rolls down an inclined plane, and one goes down a curved ramp, all without friction, and all going down the same vertical distance. Just before they reach the bottom, the one with the highest speed is the one that [17?] _____. 1) went forward into the air 2) went down the inclined plane 3) went down the curved ramp 4) neither... same for all.

17. They are the same because the potential energy change is the same for both. This goes into the same change in kinetic energy.

A 500 kg stone is pulled up a greased ramp (there is still friction) at constant speed, angled 25° above horizontal, to build a pyramid. If the stone is slowly pulled 30 meters in 800 seconds up the incline by a force of 1720N from ropes directed along the incline, the work done by the rope pullers is [18?] _____ (a) less than 50000 N (b) 50000 – 51000 (c) 51000 – 52000 (d) 52000 – 53000 (e) 53000 – 54000 (f) more than 54000 N.

The power provided by the rope pullers is [19?] _____ (a) Less than 52 W (b) 52 – 56 (c) 56 – 60 (d) 60 – 64 (e) 64 – 68 (f) 68 – 72 (g) more than 72 W.



If there is no significant velocity, the work done against friction must have been [20?] _____ (a) less than 400 kJ (b) 400 – 420 (c) 420 – 440 (d) 440 – 460 (e) 460 – 480 (f) 480 – 500 (g) 500 – 520 (h) 520 – 540 (i) more than 540 kJ.

18. $W = F_{\parallel} \Delta x = 1720 \cdot 30; = 51600 \text{ J.}$

19. $P = W/t = 51600/800; = 64.5 \text{ W}$

20. Put $y = 0$ at bottom: $E_{bef} + W_{net} = E_{aft} \rightarrow 0 + W_{pullers} - |W_{friction}| = PE_f$

$|W_{fric}| = W_{pullers} - PE_f = 51600 \text{ J} - mgh = 51600 \text{ J} - mg \sin \theta = 51600 - 500 \cdot g \cdot 30 \cdot \sin$

(20) = 1323 J sorry about the wrong answer ranges, and sorry that this number was initially incorrect! The angle in the problem was initially incorrect also!

In the electrical force between a nucleus and an electron, the work done in moving the electron in the space around the nucleus depends only on the initial and final distances between the nucleus and the electron. This electrical force is [21?] _____. 1) conservative 2) nonconservative 3) depends on the time it takes.

21. Conservative forces depend only on initial and final positions.

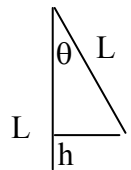
Tarzan, mass 80 kg, is jogging at 1 m/s when he hears a lion behind him. He runs even faster and at the end of 20m is now going 3 m/s. Over the 20 m of distance he did [22?]_____ (a) less than 295 J (b) 295 – 305 (c) 305 – 315 (d) 315 – 325 (e) 325 – 335 (f) more than 335 J of work.

Still going 3 m/s, he now grabs a vine of length 4 m and swings over a river, and if he hangs on until he stops in his swing, he will be at an angle from the vertical of [23?]_____ (a) 23 – 24 degrees (b) 24 – 25 (c) 25 – 26 (d) 26 – 27 (e) 27 – 28 (f) 28 – 29 (g) 29 – 30 (h) 30 – 31 (i) more than 31 degrees.

If instead he lets go of the vine while he is 0.25 m off the ground, his speed when he lets go will be [24?]_____ (a) less than 1.4 m/s (b) 1.4 – 1.5 (c) 1.5 – 1.6 (d) 1.6 – 1.7 (e) 1.7 – 1.8 (f) 1.8 – 1.9 (g) more than 1.9 m/s

$$22: \frac{1}{2}mv_i^2 + W = \frac{1}{2}mv_f^2 \quad W = \frac{1}{2}m(v_f^2 - v_i^2) = 1/2 * 80*(3^2 - 1^2); = 320 \text{ J}$$

$$23: \frac{1}{2}mv_i^2 + 0 = 0 + mgh \quad h = \frac{v_i^2}{2g} = 3^2/2/g = 0.4592 \text{ m}$$



$$h = L - L\cos\theta \quad \cos\theta = 1 - h/L \quad \theta = \text{acos}(1 - 0.459/4) = 27.7 \text{ deg}$$

$$24: \frac{1}{2}mv_i^2 + 0 = \frac{1}{2}mv_f^2 + mgh \quad v_f = \sqrt{v_i^2 - 2gh} = \text{sqrt}(3^2 - 2*g*0.25); = 2.025 \text{ m/s}$$

You move a load of bricks of mass 28 kg slowly so it never gets significant velocity. First you move the bricks to a new floor that is 4 m above you, and the work you did on the bricks was [25?]_____ (a) less than 950 J (b) 950 – 1000 (c) 1000 – 1050 (d) 1050 – 1100 (e) 1100 – 1150 (f) more than 1150 J.

You now carry the bricks across the floor a distance of 2 m, and the work you did on the bricks was [26?]_____ (a) less than -500 J (b) -500 to -300 (c) -300 to -100 (d) -100 to 100 (e) 100 to 300 (f) 300 to 500 (g) more than 500 J.

$$25. W = F_{\parallel}\Delta x = F\cos\theta\Delta x = mgh = 28*g*4; = 1098 \text{ J}$$

$$26. W = F_{\parallel}\Delta x = F\cos\theta\Delta x \quad \cos\theta = 0, \text{ so } W = 0 \text{ (force is perpendicular to path)}$$

A skydiver is falling, and opens his parachute, and slows down. Which is greatest on the man right after he opens the chute: [27?]_____ 1) force of gravity 2) force of chute 3) they are the same. He now is falling at a constant speed. Which is greatest on the man now? [28?]_____ 1) force of gravity 2) force of chute 3) they are the same.

27. His acceleration is upward (he's slowing down), and so he must have a net upward force. Choice (2) is correct.

28. His acceleration is zero, so forces have to cancel. Choice (3) is correct.