Name	Section	Date	Score
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Phys 20.01 Long exam 2

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2025 W40

Instructions: For comprehension and conceptual questions, choose the best answer. For problem-solving questions, choose the best answer and show your solution and reasoning. Comprehension is 1 pt each, conceptual is 2 pt each, and problem-solving is 3 pt each.

1. Comprehension

1. Newton's first law of motion is fundamentally a statement about which property of an object?
   a. force
   b. acceleration
   c. inertia
   d. weight

2. If an object is moving at a constant velocity in a straight line, which is true about net external force acting on it?
   a. net force is directed forward
   b. net force is zero
   c. net force is equal to the weight of the object
   d. net force is in the direction of motion

3. A free-body diagram shows the forces acting on an object. How is that object represented in the diagram?
   a. A single point
   b. A square box
   c. A unit circle
   d. The object as it is

4. In the equation $F_{\text{net}} = ma$, the term F_{net} represents
   a. force of gravity
   b. total number of forces acting on the object
   c. vector sum of all external forces on the object
   d. force applied by the primary external agent

5. How do you express, mathematically, that no external force is acting on a body?
   a. $F_{\text{net}} = 0$
   b. $F_{\text{net}} = 1$
   c. $F_{\text{net}} = \infty$
   d. F_{net} does not exist

6. What does it mean for two quantities a and b to be inversely proportional to each other?
   a. When a increases, b also increases
   b. When a increases, b decreases by a greater amount
   c. When a increases, b decreases by the same factor
   d. When a increases, b also increases by same factor

7. A long-range force, unlike a contact force, is known for
   a. being always repulsive
   b. requiring the two objects to be touching
   c. being caused solely by air resistance
   d. acting even when the two interacting objects are separated

8. When a material is stretched below its proportional limit, and the stretching force is removed, the material
   a. fractures immediately
   b. remains permanently deformed
   c. returns to its original shape and size
   d. continues to stretch

9. Which statement is true regarding the coefficients of friction for a given pair of surfaces?
   a. μ_k is equal to μ_s
   b. μ_k is always greater than μ_s
   c. μ_s is generally greater than μ_k
   d. μ_s is dependent only on the speed of the object

10. True or false. Newton's second law can be interpreted based on Newton's first law.
    a. True
    b. False

11. A ball is dropped and hits the floor. What is the direction of the force exerted by the floor on the ball?
    a. upward
    b. downward
    c. right
    d. left

12. The microscopic origin of friction and normal force is
    a. intermolecular electrical forces at points of contact
    b. overall smoothness or roughness of bulk material
    c. quantum entanglement
    d. magnetic attraction

13. A cable supports a weight. The force exerted by cable on the weight, acting along the length of the cable, is
    a. normal force
    b. support force
    c. tension force
    d. tensile stress

14. The universal gravitational constant G describes the strength of the gravitational force
    a. between any pair of objects in the universe
    b. only near the surface of a planet
    c. between any object and earth
    d. only for objects in orbit

15. Cavendish experiment marked a milestone in the study of gravity. Why was this so hard in terms of masses used in apparatus and strength of gravitational force?

a. Gravity is a very strong force, but creating perfectly spherical masses to ensure uniform gravitational fields and prevent uneven attraction was difficult
b. Gravity is a very strong force, but the experimental setup made it appear weak because the small distances amplified other, confounding forces
c. Gravity is a very weak force but despite this limitation, Cavendish was able to measure the attraction between very massive objects
d. Gravity is a very weak force but despite this limitation, Cavendish was able to measure the attraction between less massive objects

2. Conceptual

1. A ball rolls along the ground, moving from north to south. What direction is the frictional force that acts on the ball?
   a. north to south
   b. south to north
   c. west to east
   d. east to west

2. According to Newton's third law, when a horse pulls a cart, the force that propels the system forward is the
   a. horse's pull on the cart
   b. cart's pull back on the horse
   c. force of horse's hooves pushing backward on road
   d. force of the road pushing forward on horse's hooves

3. An object is placed on an inclined plane. The force of gravity acting on the object is always directed
   a. straight down towards the center of the earth
   b. perpendicular to the ramp
   c. parallel to the ramp
   d. away from the ramp

4. A large truck collides head-on with a small car. During collision, which vehicle experiences greater force?
   a. the large truck
   b. the small car
   c. it depends on the initial speeds of the vehicles
   d. the forces are equal in magnitude, according to Newton's third law

5. Why does an astronaut in an orbiting spacecraft feel "weightless"?
   a. spacecraft is moving at a very high speed
   b. spacecraft and astronaut are in constant free fall together
   c. gravitational force is balanced by the engine thrust
   d. gravitational force from earth is zero in orbit

6. If a hypothetical planet were discovered that had half the earth's radius and half the earth's mass, the acceleration due to gravity g on its surface would be
   a. half the earth's g
   b. same as earth's g
   c. twice the earth's g
   d. four times the earth's g

7. A spring is hung vertically, and a weight is attached, stretching the spring. The stretching force is
   a. proportional to the amount the spring is stretched
   b. proportional to spring's maximum possible stretch
   c. inversely proportional to amount spring is stretched
   d. independent of the amount the spring is stretched

8. Two ropes are used to support a sign, with each rope making a 45° angle with horizontal. How does tension T in each rope compare to weight W of the sign?
   a. $T = W$
   b. $T = W/2$
   c. $T > W/2$
   d. $T < W/2$

9. A person is trying to decide whether to push or pull a luggage cart at a constant speed. The pushing or pulling force is applied at an angle. To minimize the magnitude of pushing or pulling force, they should
   a. push the cart
   b. pull the cart, applying force upward at an angle
   c. pull the cart, applying force downward at an angle
   d. it makes no difference, as long as angle is the same

10. An applied force F_{app} is pushing horizontally on a heavy crate. The crate does not move. The magnitude of the static friction force f_s is
    a. equal to $\mu_s N$, where N is normal force
    b. always greater than F_{app}
    c. equal to F_{app}
    d. zero

11. A 20-kg wagon is released from rest from the top of a 15-m-long plane, which is angled at 30° with the horizontal. Assuming there is friction between the ramp and the wagon, how is this frictional force affected if the angle of the incline is increased?
    a. frictional force increases
    b. frictional force decreases
    c. frictional force remains the same
    d. it cannot be determined from the information given

12. A house cat typically weighs 45 N. How many pounds does it weigh, and what is its mass in kilograms?
    a. 10.1 lbs, 4.59 kg
    b. 10.1 lbs, 45 kg
    c. 20.2 lbs, 4.59 kg
    d. 20.2 lbs, 45 kg

13. As astronaut weights 700 N on earth. What will her weight be on a planet with a radius that is two times that of earth, and a mass three times that of earth?
    a. 200 N
    b. 500 N
    c. 700 N
    d. 900 N

14. A person stands on a scale in an elevator. The scale reads a value less than the person's true weight. The elevator must be
    a. moving upward at a constant velocity
    b. accelerating downward

c. accelerating upward
d. moving downward at a constant velocity

15. A car stopped because of the second and third laws. During impact, the car exerted a force on the tree. As per third law, the tree exerted an equally strong force back on the car. As per second law, the force of the tree on the car gave the car an acceleration that changed its velocity to zero. Considering this explanation, which of law is more to blame for the car coming to a stop?
    a. Third law is most responsible, as it describes force exerted by the tree, which directly stopped the car
    b. First law (inertia) is most to blame, as the car's tendency to continue moving forward is what made the collision and subsequent stopping necessary
    c. Second law is most responsible, as it directly links the force exerted on the car to the change in its velocity, causing it to stop. Third law simply describes the interaction
    d. Both second and third laws are equally to blame, as they are both essential for the car to come to a stop

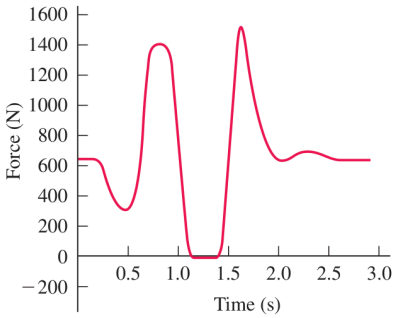
3. Problem solving

Forces on a dancer's body, revisited. Dancers experience large forces associated with the jumps they make. For example, when a dancer lands after a vertical jump, the force exerted on the head by the neck must exceed the head's weight by enough to cause the head to slow down and come to rest. The head is about 9.4% of a typical person's mass. Video analysis of a 65 kg dancer landing after a vertical jump shows that her head decelerates from 4.0 m/s to rest in a time of 0.20 s.

1. The forces on a dancer can be measured directly when a dancer performs a jump on a force plate that measures the force between her feet and the ground. A graph of force versus time throughout a vertical jump performed on a force plate is shown in the figure. What is happening at 0.4 s? The dancer is
    a. in the air and at the top of her jump
    b. landing and her feet have just touched the ground
    c. bending her legs so her body accelerates downward
    d. pushing her body up with her legs and is almost ready to leave the ground

    When the dancer is not moving, the force that the force plate exerts on her will be her weight, which appears to be about 650 N. Between 0.0 s and 0.4 s, the force on her is less than her weight and is decreasing, so she must be accelerating downward. At 0.4 s, the graph reaches a relative minimum of around 300 N and then begins to increase after that. Only our chosen option is consistent with this part of the graph.

    At the high points in the graph, the force on her is over twice her weight.



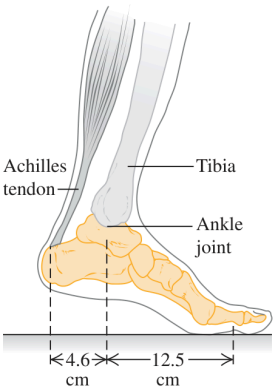
Tendon-stretching exercises. As part of an exercise program, a 75 kg person does toe raises in which he raises his entire body weight on the ball of one foot as in the figure. The Achilles tendon pulls straight upward on the heel bone of his foot. This tendon is 25 cm long and has a cross-sectional area of 78 mm^2 and a Young's modulus of 1470 MPa. During this exercise, this tendon exerts 2000 N on the heel, equivalent to 2.72 times his weight.

1. By how many millimeters does the exercise stretch his Achilles tendon?
    a. 0.44 mm
    b. 2.65 mm
    c. 4.36 mm
    d. 6.12 mm

    The foot pulls downward on the tendon with a force of 2000 N.

$$\begin{aligned}\Delta l &= \left(\frac{F_T}{YA}\right) l_0 \\ &= \frac{2000\ \text{N}}{(1470 \times 10^6\ \text{Pa})(78 \times 10^{-6}\ \text{m}^2)}(25\ \text{cm}) \\ &= 4.4\ \text{mm}\end{aligned}$$

    The tension is quite large, but the Achilles tendon stretches about 4.4 mm, which is only about 1/6 of an inch, so it must be a strong tendon.



Meme caption time! The funniest take gets featured.

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