

SOLUTIONS to C.P. Review, Ch. 4, 5 + 6

Sample Questions and Calculations

1. If you were in a spaceship and launched a cannonball into frictionless space, how much force would have to be exerted on the ball to keep it moving at a constant velocity? Explain in terms of Newton's laws of motion.

Once the cannonball was launched, it would require zero force to keep it moving at constant velocity. Newton's first law says "an object in motion will continue in a straight line with constant speed (= constant velocity) unless acted upon by an outside force."

2. Does a 2-kilogram rock have twice the mass of a 1-kilogram rock? Twice the inertia? Twice the weight (when weighed in the same location)?

Yes, a 2-kg rock has twice the mass, inertia and weight of a 1-kg rock, as long as they are weighed in the same location. Mass is a measure of inertia, and weight is directly proportional to mass. $W = mg$

3. If you hold a coin above your head while in a bus that is not moving (relative to the earth), the coin will land at your feet when you drop it. Where will it land if you drop it while the bus is moving in a straight line at constant speed (relative to the earth)? Explain in terms of Newton's laws of motion.

The coin will land at your feet in a bus moving at constant velocity. When dropped, the coin is already moving with the same horizontal speed as the bus and no horizontal force acts to change that, (Newton's 1st Law) so it continues forward at that speed.

4. Calculate in Newtons the weight of a 2.5 kg melon.

$$W = mg \quad W = (2.5 \text{ kg})(9.8 \text{ m/s}^2)$$

$$W = 24.5 \text{ N}$$

$$\boxed{\rightarrow 25 \text{ N}}$$

5. Susie Small weighs 300N. Explain what this means in terms of her gravitational interaction with the earth. Calculate Susie's mass in kilograms. Would her weight or her mass change if she were on a different planet? The earth exerts a force of 300N on Susie, and Susie exerts a force of 300N on the earth. Her weight might change on a different planet but her mass would remain constant.

$$W = mg \quad m = \frac{W}{g} \quad m = \frac{300 \text{ N}}{9.8 \text{ m/s}^2} \quad \boxed{m = 30.6 \text{ kg}}$$

6. When you compress a sponge, what changes: its mass, its inertia, its weight, or its volume?

Assuming you don't squeeze any liquid out of the sponge, its mass, inertia and weight remain unchanged, but its volume decreases.

7. If I went to a planet that had twice the gravity of earth, how would that affect my mass? How would it affect my weight?

In this case, mass would remain constant but weight. (the force of gravity on an object) would double.

8. What is the net force acting on an object in static equilibrium? In dynamic equilibrium?

In static equilibrium forces are balanced and $F_{net} = 0$.
In dynamic equilibrium, net force also equals zero.

9. True or false: If no force acts on a moving object, the object will eventually come to a stop. If it's false, explain why.

False. If no force (no net force) acts on a moving object it will continue in motion in a straight line at constant speed. (Newton's 1st Law) If the object comes to a stop it is because there is a net force acting on it to oppose the motion.

10. Suppose a pilot announces that the plane is flying at a constant 900km/h and the thrust of the engines is a constant 80,000 N.

a. What is the acceleration of the airplane? constant speed (and direction)

$$\text{so } a = 0$$

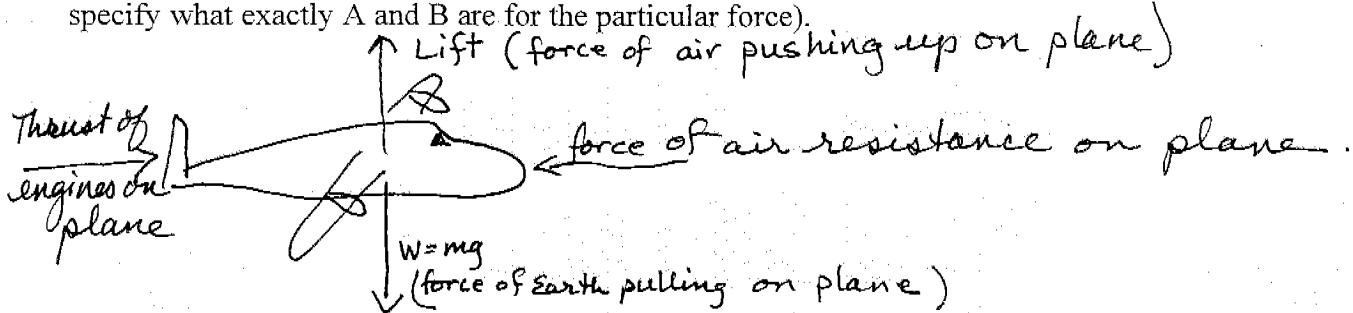
b. What is the net force acting on the airplane?

$$F_{net} = 0$$

c. Are there any other forces that you can identify that are acting on the airplane other than the push of its engines?

Air resistance must be acting in the opposite direction, making $F_{net} = 0$.

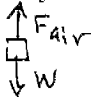
d. Draw a picture of the plane with vectors representing all forces acting on the plane. Label each force vector with what it represents (for example, "Force of A pushing on B" or "Force of B pulling on A", but specify what exactly A and B are for the particular force).



11. Describe the motion of an object of fixed mass when a constant force is applied to it. Discuss whether it is moving or not, and what you know about its velocity and its acceleration. Think about the skateboard lab (some of you did not use actual skateboards, but used a small cart loaded with weights).

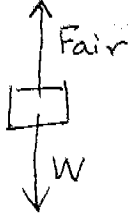
When a constant force (greater than friction) is applied to an object, the object's velocity will increase. As long as net force is constant and mass of the object it acts on is constant, the acceleration will also be constant and the object will increase at a constant rate.

12. a. When the force of air resistance on a falling object is equal to the object's weight, what is the net force on the object? (Think about the direction in which each force (weight and air resistance) acts.)



When these two forces are equal, $F_{net} = 0$

b. Draw a picture of the object and use force vectors to represent all forces acting on the falling object.



c. What is the acceleration of the object? Because $F_{net} = 0$, $a_{must} = 0$.

d. Does that mean that the object abruptly comes to a halt in midair at the instant that air resistance equals weight? Explain. No. It means that it reaches a constant (nonzero) speed and continues falling at that speed without accelerating.

13. A skydiver jumps from a high-altitude balloon. Answer each of the following questions in a complete sentence or two.

a. As she falls through the air, does her velocity increase, decrease, or stay the same?

As she falls her velocity increases.

b. Does air resistance increase, decrease, or stay the same?

air resistance increases as her speed increases.

c. Does the force exerted on her by gravity increase, decrease, or stay the same?

The force of gravity is proportional to her mass and it remains the same. ($W = mg$)

d. Does the net force on her increase, decrease, or stay the same?

The net force on her decreases as air resistance increases.

e. Does her acceleration increase, decrease, or stay the same? acceleration also

decreases as net force decreases.

14. After she jumps, a skydiver reaches terminal velocity after 10 seconds.

a. Does she gain more speed during the first second of fall or the ninth second of fall?

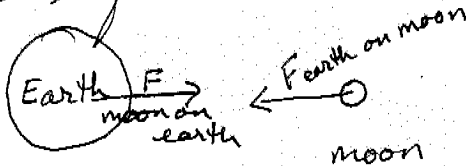
She gains more speed during the first second of fall.

b. Compared with the first second of fall, does she fall a greater or lesser distance during the ninth second of fall?

She falls a greater distance during the ninth second because her speed is greater by then.

15. We know that the Earth pulls on the moon. Does the moon also pull on the earth? Which pull is stronger? Explain in terms of Newton's laws of motion. Which one of Newton's laws refers to interactions between two objects? Draw a picture of the earth and the moon, including force vectors representing the interaction between the two objects. Label each force vector with words, like you did in problem # 10.

The moon pulls on the earth with a force equal in magnitude to the force of the earth on the moon. These two forces are an action-reaction pair as referred to in Newton's Third Law.



16. Apply Newton's third law to a tug-of-war. If the action is you pulling on the rope, is the reaction force the ground pushing back on you or your opponent pulling back on the rope or something else?

If the action force is you pulling on the rope, the reaction force must be the rope pulling on you.

17. Describe the relative motions of two people of equal mass who push off from each other on slippery ice. Then describe the relative motions of two people of different masses who push off each other on the ice. Use Newton's laws of motion in your explanations. Discuss the magnitudes of the forces involved as well as the resulting accelerations of the two people.

If two people push off from each other, they are each pushed by an equal force but in opposite directions. (3rd Law) If the masses are equal, their accelerations are equal. If one has a greater mass it will have a smaller acceleration, because mass and acceleration are inversely proportional, (2nd Law). They will then move away at constant velocity unless friction with the ice slows this motion. (1st Law)

18. What is the acceleration given to a 30-kg block of cement when it is pulled sideways with a net force of 600 N?

$$\boxed{30 \text{ kg}} \xrightarrow{600 \text{ N}} a = \frac{F}{m} = \frac{600 \text{ N}}{30 \text{ kg}} = \boxed{20 \text{ m/s}^2}$$

19. A 600-kg car and an 1800-kg truck both go from zero to sixty miles per hour in 10 seconds flat. Calculate the acceleration of each vehicle, including units with your answer. Do they have the same acceleration? Is the same force required to cause this amount of acceleration in each vehicle? Explain using Newton's laws of motion.

$$a = \frac{\Delta v}{t} = \frac{60 - 0 \text{ m/s}}{10 \text{ sec}} = \boxed{6 \text{ m/s}^2}$$

Yes, they have the same change in velocity in the same amount of time.

$$F = ma$$

car:

$$F = (600 \text{ kg}) (6 \text{ m/s}^2)$$

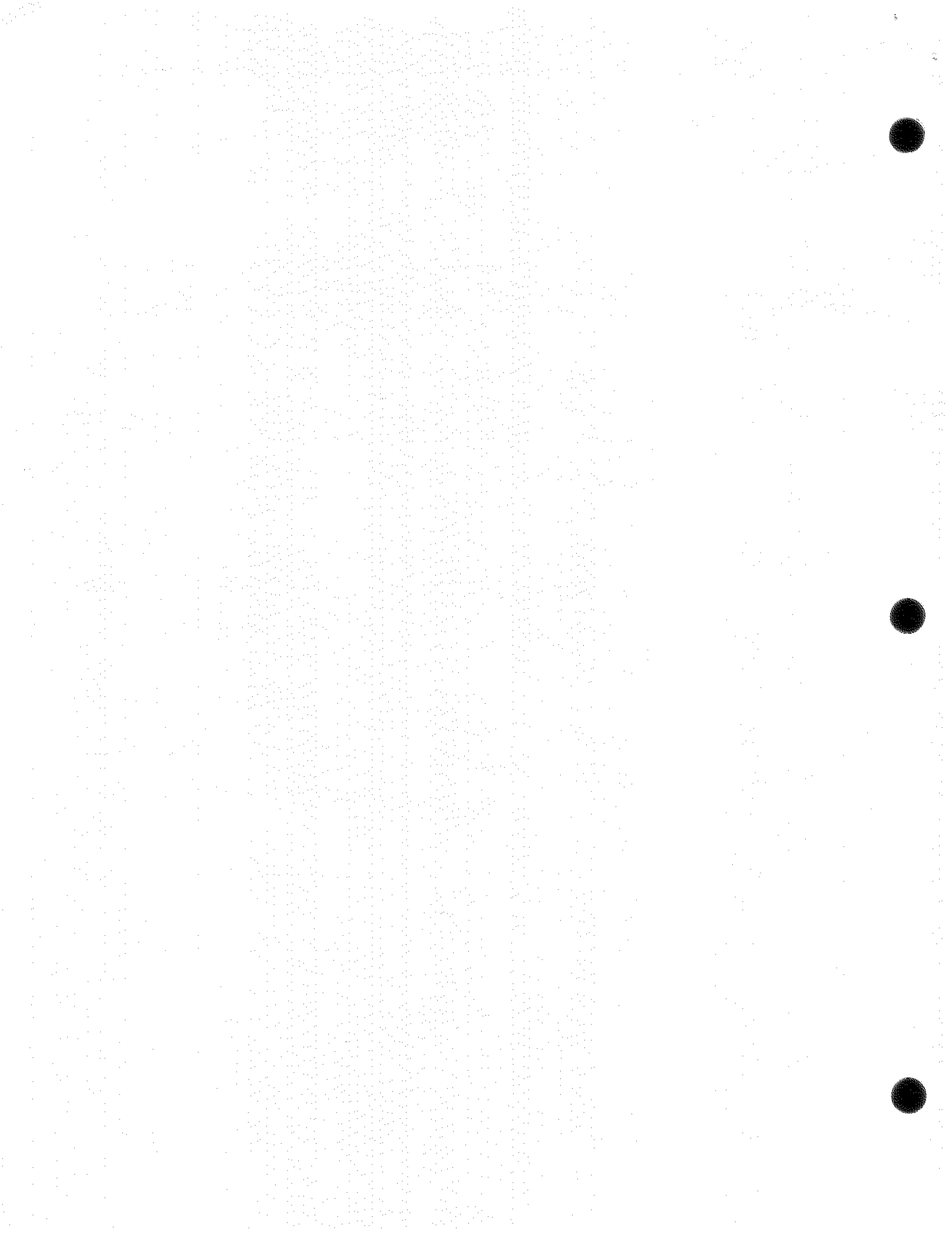
$$\underline{F = 3600 \text{ N}}$$

truck

$$F = (1800 \text{ kg}) (6 \text{ m/s}^2)$$

$$\underline{F = 10800 \text{ N}}$$

The force required to accelerate the truck, which has three times the mass, is three times as great as the force required to accelerate the car.



(revised)

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$F = ma$. If both trucks have the same acceleration, the truck with three times the mass will require three times as much force to produce that acceleration.

Conversion practice

Convert 60 mi/hr to meters per second:

$$\frac{60 \text{ mi}}{\text{hr}} \times \frac{1 \text{ hr}}{3600 \text{ sec}} \times \frac{1609 \text{ m}}{1 \text{ mi}} = \boxed{26.8 \text{ m/sec}}$$

