Physics Workshop
Newton's Laws in 1-D
Suggested Checkpoint Questions with Answers

- Checkpoint following 1(e):

1. Why do you suppose you were asked about the *average* net force on the car in 5(a)?
2. What does the word "normal" in "normal force" mean?

- Checkpoint following 2(d):

1. Why don't forces like the "engine force" or "force of brakes" get included on your free-body diagrams for the car?
2. Can you think of a rule to describe the direction of static friction (the friction that prevents something from sliding)?

- Checkpoint following 3:

1. If a rope is supporting a hanging mass, does this mean that the tension in the rope is constant?
2. How would you take into account the rope's own mass?

- Checkpoint following 4:

1. Make a graph of the normal force versus time for the bounce. Is it *always* greater than the weight of the ball?

Answers to checkpoint questions:

- Checkpoint following 1(e):

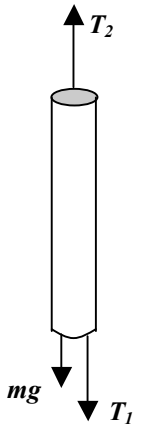
1. Typically, the acceleration of a car is not constant, but varies as the car moves and changes gears. So the average acceleration given in the problem really is an average and not a constant. Therefore the force producing the acceleration is also not constant, and we are only able to find its average from the information given.
2. The word "normal" means "perpendicular" in mathematics. This word is therefore a reminder that the normal force is the force exerted by a surface, perpendicular to that surface. If you really want to inflict pain on your physics professor, try calling the normal force the "natural force".

- Checkpoint following 2(d):

1. This goes to the heart of what a free-body diagram really is. On the FBD for an object, you must include all of the forces acting on the object from outside. The engine exerts a force on the crankshaft, which exerts a force on the axle, which exerts a force on the wheels, which exert forces on the tires, which exert a force on the road, but none of these are forces on the car from outside. Instead, the results of the entire chain of forces described above is that the road exerts a force back on the tires (by Newton's 3rd Law, this is the reaction to the force of the tires on the road). This force, which is a frictional force, is the one that goes on the FBD.
2. One way to describe the direction of static friction is that it opposes an object's tendency to move (you can't say that it opposes the motion, because there is no motion!). In other words, static friction acts in the direction opposite to the way the object would move if the friction wasn't there.

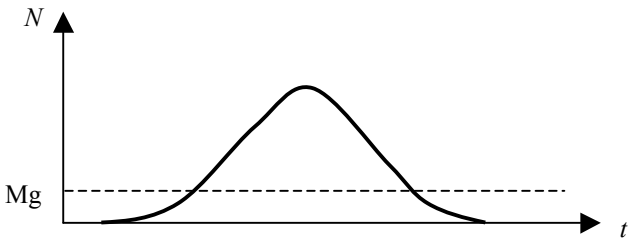
- Checkpoint following 3:

1. This problem clearly shows that, like the normal force, the force of tension has a magnitude that varies depending on the situation. Many students' intuition leads them to assume that the tension equals the weight in cases like this.
2. The students should be encouraged to make a FBD for the rope itself to answer this question. Doing so shows that when the rope's own mass is considered, the tension in the vertical rope can no longer be the same throughout the rope. Rather, the tension will be greater at the top of the rope.



- Checkpoint following 4:

1. In fact, the normal force isn't a constant force, but rather it varies from zero (before the ball contacts the ground) to some maximum and then back to zero as the ball bounces.



In reality, it's just the *average* normal force that exceeds the weight of the ball during the bounce. During those times when the weight of the ball is greater than the normal force, the ball's center of mass is accelerating downward. But the net effect of the bounce is, of course, an upward acceleration.