Double check that you bubble in your code number correctly. If there’s a mistake, your score will be lowered – as a penalty.
1. A train has 3 segments: the engine, a passenger car, and the caboose (with the passenger car in the middle). The mass of the engine is \( m_e = 5 \times 10^5 \text{kg} \), the mass of the passenger car is \( m_p = 3 \times 10^5 \text{kg} \) and the mass of the caboose is \( m_c = 1 \times 10^5 \text{kg} \). The train is accelerating at \( \vec{a} = 3 \text{m/s}^2 \hat{i} \). (Here \( \hat{i} \) points East, \( \hat{j} \) points North, and \( \hat{k} \) points straight up.)

What is the total (net) force acting on the caboose?

(a) \( \vec{F}_{\text{total}} = (3 \hat{i} - 9.8 \hat{j}) \times 10^5 \text{N} \).
(b) \( \vec{F}_{\text{total}} = 27 \hat{i} \times 10^5 \text{N} \).
(c) \( \vec{F}_{\text{total}} = 3 \hat{i} \times 10^5 \text{N} \).
(d) \( \vec{F}_{\text{total}} = 9 \hat{i} \times 10^5 \text{N} \).

2. Same setup. What is the total (net) force acting on the passenger car?

(a) \( \vec{F}_{\text{total}} = 27 \hat{i} \times 10^5 \text{N} \).
(b) \( \vec{F}_{\text{total}} = 9 \hat{i} \times 10^5 \text{N} \).
(c) \( \vec{F}_{\text{total}} = 3 \hat{i} \times 10^5 \text{N} \).
(d) \( \vec{F}_{\text{total}} = (27 \hat{i} + 9.8 \hat{j}) \times 10^5 \text{N} \).

3. Same setup. Consider the tension \( T_{ep} \) in the coupling that connects the engine to the passenger car, and the tension \( T_{pc} \) in the coupling that connects the passenger car to the caboose. Which of the following is correct?

(a) \( T_{ep} = T_{pc} \).
(b) \( T_{ep} = 4T_{pc} \).
(c) \( T_{ep} = 8T_{pc} \).
(d) \( T_{ep} = 9T_{pc} \).

4. Find the tension \( T_{ep} \) in the coupling that connects the engine to the passenger car.

(a) \( T_{ep} = 27 \times 10^5 \text{N} \).
(b) \( T_{ep} = 9 \times 10^5 \text{N} \).
(c) \( T_{ep} = 12 \times 10^5 \text{N} \).
(d) \( T_{ep} = 3 \times 10^5 \text{N} \).

5. The same train, but a different question is now being asked. Suppose that the couplings will break if any of their tensions exceed \( 4 \times 10^6 \text{N} \). What is the minimum time needed to go from rest, \( v_0 = 0 \), to a final velocity \( v_f = 20 \text{m/s} \), in order to ensure that the couplings don’t break? (In other words, if the time is anything shorter than this
time, the coupling would break.) The velocity change is thanks to a constant force exerted by the engine.

(a) 2s  
(b) 4s  
(c) 5s  
(d) 10s

6. Henrietta weighs 500 N. She is also an unbelievably fantastic runner: the only limitation to her acceleration is that her shoes can only provide a maximum of 100 N of friction force.

Which most closely approximates Henrietta’s maximum acceleration (before her shoes start slipping).

a) 2 m/s$^2$.  
b) 3 m/s$^2$  
c) 4 m/s$^2$  
d) 10 m/s$^2$.

7. Henrietta steps out of her apartment building and runs with her maximum acceleration to get to her physics quiz on time. Since she “forgot” her bagel again, Bruce uses his bagel bazooka to send the bagel out the window, firing the bagel out horizontally from their apartment window, 20 m above street level, with a horizontal velocity of 50 m/s. Go ahead and approximate $9.8 \approx 10$.

How far down the street from the apartment building would the bagel land?

(a) 10 m  
(b) 50 m  
(c) 70 m.  
(d) 100 m

8. How long after Henrietta starts running out their apartment building door should Bruce wait, before firing the bagel out (with the velocity described in the previous question)?

(a) 2 s  
(b) 4 s  
(c) 8 s  
(d) 10 s.
9. An athlete who weighs 800\,N lifts a barbell of weight 490\,N. He lifts the barbell a distance of 0.5\,m in 0.5\,s. All this time, he is also standing on a scale. What weight does the scale show during the lifting time?
(a) 800\,N.
(b) 1000\,N
(b) 1290\,N.
(c) 1490\,N.

10. Alice and Bob and Charlie are children, and they each want to play with a special toy, so they each pull on it with their maximum force. At a given instant, the toy does not move. The force Alice exerts on the toy is \( \vec{F}_A = 100\,\hat{i} \). Bob’s exerted force is 80\,N, directed at 120° relative to Alice’s. What force is Charlie exerting on the toy?
(a) \( \vec{F}_C = -60\,\hat{i} - 40\sqrt{3}\,\hat{j} \).
(b) \( \vec{F}_C = -140\,\hat{i} - 40\sqrt{3}\,\hat{j} \).
(c) \( \vec{F}_C = 60\,\hat{i} + 40\sqrt{3}\,\hat{j} \).
(d) \( \vec{F}_C = 140\,\hat{i} + 40\sqrt{3}\,\hat{j} \).

11. A helicopter is descending to earth, with downward acceleration \( g/5 \) (where \( g = 9.8\,m/s^2 \)). A passenger, whose usual weight is 800\,N, is standing on a scale. What is the reading on the scale in the descending helicopter?
(a) 160\,N
(b) 640\,N
(c) 800\,N
(d) 960\,N.

12. Same setup, except this time the helicopter is ascending, with upward acceleration \( g/5 \) (where \( g = 9.8\,m/s^2 \)). A passenger, whose usual weight is 800\,N, is standing on a scale. What is the reading on the scale in the ascending helicopter?
(a) 160\,N
(b) 640\,N
(c) 800\,N
(d) 960\,N.