



## AP<sup>®</sup> Physics B 2003 Sample Student Responses

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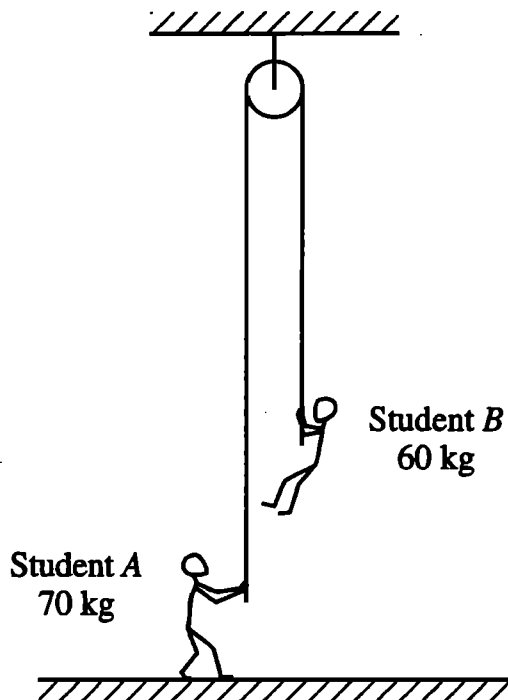
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**PHYSICS B**  
**SECTION II**  
**Time—90 minutes**  
**7 Questions**

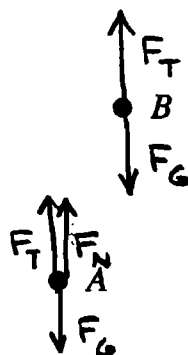
**Directions:** Answer all seven questions, which are weighted according to the points indicated. The suggested time is about 15 minutes for answering each of questions 1-4, and about 10 minutes for answering each of questions 5-7. The parts within a question may not have equal weight. Show all your work in this booklet in the spaces provided after each part, NOT in the green insert.



1. (15 points)

A rope of negligible mass passes over a pulley of negligible mass attached to the ceiling, as shown above. One end of the rope is held by Student A of mass 70 kg, who is at rest on the floor. The opposite end of the rope is held by Student B of mass 60 kg, who is suspended at rest above the floor.

(a) On the dots below that represent the students, draw and label free-body diagrams showing the forces on Student A and on Student B.



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- (b) Calculate the magnitude of the force exerted by the floor on Student A.

$$\Sigma F_A = Ma = 0$$

$$\Sigma F_A = F_T + F_N - F_G = 0$$

$$\Sigma F_B = Ma = 0$$

$$\Sigma F_B = F_T - F_G = 0$$

$$F_T = F_G$$

$$F_T = Mg$$

$$F_T = (60\text{kg})(9.8\text{m/s}^2)$$

$$F_T = 588\text{ N}$$

$$\Sigma F_A = F_T + F_N - F_G = 0$$

$$F_N = F_G - F_T$$

$$F_N = Mg - F_T$$

$$F_N = (70\text{kg})(9.8\text{m/s}^2) - 588\text{ N}$$

$$F_N = 98\text{ N}$$

Student B now climbs up the rope at a constant acceleration of  $0.25\text{ m/s}^2$  with respect to the floor.

- (c) Calculate the tension in the rope while Student B is accelerating.

$$\Sigma F_B = Ma$$

$$\Sigma F_B = F_T - F_G$$

$$F_T - F_G = Ma$$

$$F_T = Ma + Mg$$

$$F_T = (60\text{kg})(0.25\text{m/s}^2) + (60\text{kg})(9.8\text{m/s}^2)$$

$$F_T = 603\text{ N}$$

- (d) As Student B is accelerating, is Student A pulled upward off the floor? Justify your answer.

$$\Sigma F_A = F_T + F_N - F_G$$

$$F_T = 603\text{ N}$$

$$\Sigma F_A = 603\text{ N} + \underline{\underline{F_N}} - (70\text{kg})(9.8\text{m/s}^2)$$

$$F_G = 686\text{ N}$$

Student A is <sup>not</sup> being pulled upwards off the floor because the change in tension simply reduces the normal force (the force exerted by the floor). It does not overcome the force of gravity exerted on student A.

- (e) With what minimum acceleration must Student B climb up the rope to lift Student A upward off the floor?

$$F_T > F_G$$

$$F_T > 686\text{ N}$$

$$Ma = F_T - F_G$$

$$a = \frac{F_T - F_G}{M}$$

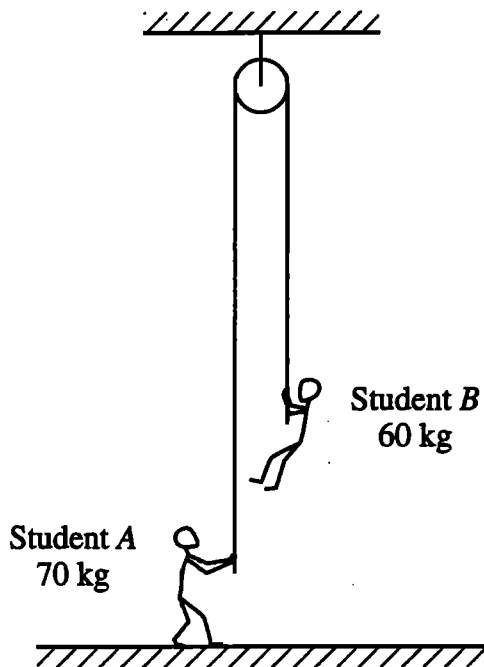
$$a = \frac{686\text{ N} - (60\text{kg})(9.8\text{m/s}^2)}{60\text{ kg}}$$

$$a = 1.63\text{ m/s}^2$$

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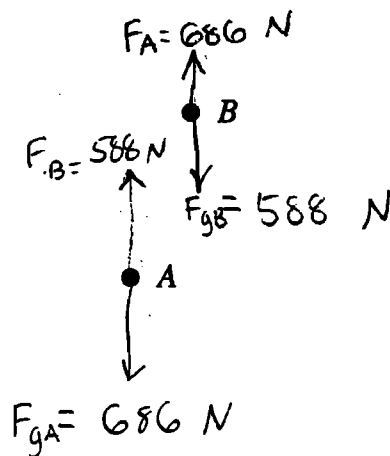
1. (15 points)

A rope of negligible mass passes over a pulley of negligible mass attached to the ceiling, as shown above. One end of the rope is held by Student A of mass 70 kg, who is at rest on the floor. The opposite end of the rope is held by Student B of mass 60 kg, who is suspended at rest above the floor.

(a) On the dots below that represent the students, draw and label free-body diagrams showing the forces on Student A and on Student B.

$$F_{gA} = 70 \text{ kg} \times 9.8 \frac{\text{m}}{\text{s}^2} = 686 \text{ N}$$

$$F_{gB} = 60 \text{ kg} \times 9.8 \frac{\text{m}}{\text{s}^2} = 588 \text{ N}$$



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(b) Calculate the magnitude of the force exerted by the floor on Student A.

$$F_{gA} - F_B$$

$$70 \text{ kg} \times 9.8 \frac{\text{m}}{\text{s}^2} - 60 \text{ kg} \times 9.8 \frac{\text{m}}{\text{s}^2} = \underline{98 \text{ N}}$$

Student B now climbs up the rope at a constant acceleration of  $0.25 \text{ m/s}^2$  with respect to the floor.

(c) Calculate the tension in the rope while Student B is accelerating.

$$60 \text{ kg} \times \left( 9.8 \frac{\text{m}}{\text{s}^2} + 0.25 \frac{\text{m}}{\text{s}^2} \right) = \underline{603 \text{ N}}$$

(d) As Student B is accelerating, is Student A pulled upward off the floor? Justify your answer.

No. The tension in the rope ( $603 \text{ N}$ ) is less than the weight of student A ( $686 \text{ N}$ ).

(e) With what minimum acceleration must Student B climb up the rope to lift Student A upward off the floor?

$$70 \text{ kg} \times 9.8 \frac{\text{m}}{\text{s}^2} = 60 \text{ kg} \times \left( 9.8 \frac{\text{m}}{\text{s}^2} + a \right)$$

$$686 \text{ N} = 588 \text{ N} + 60a$$

$$98 \text{ N} = 60a$$

$$\underline{1.6333 \text{ m/s}^2 = a}$$

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