NAME: _____

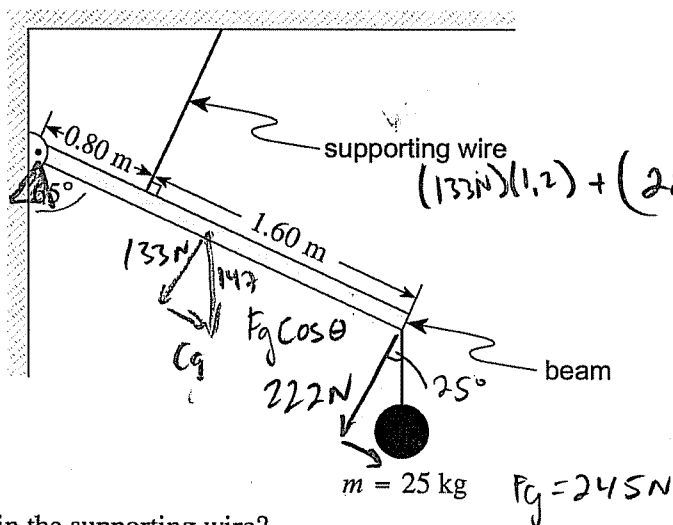## Torque and Equilibrium Review

1.

A 15 kg uniform beam 2.40 m long is suspended from a wall and a ceiling as shown.

Handwritten notes:
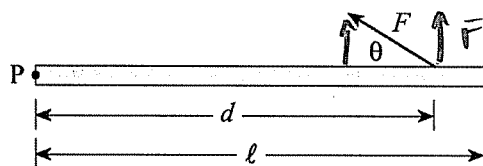$$\Sigma \tau = 0$$
$$CW\tau = CCW\tau$$
$$(133N)(1.2) + (222N)(2.4m) = T(.8m)$$
$$T = 865N$$

Diagram labels: supporting wire, beam, 0.80 m, 65°, 1.60 m, 133 N, 147, $F_g \cos\theta$, C_g, 222N, 25°, $m = 25$ kg, $F_g = 245N$

What is the tension in the supporting wire?

A. 670 N
B. 740 N
C. 870 N
D. 960 N

2.

A force F is applied to a uniform horizontal beam as shown in the diagram below.

Diagram labels: F, θ, $F\sin\theta$, P, d, ℓ

Handwritten:
$$\tau = F_\perp \cdot d$$
$$= F\sin\theta \, d$$

Which of the following is a correct expression for the torque on the beam about pivot point P due to this force?

A. $F\sin\theta \cdot d$
B. $F\sin\theta \cdot d/\ell$
C. $F\cos\theta \cdot d$
D. $F\cos\theta \cdot d/\ell$

3.

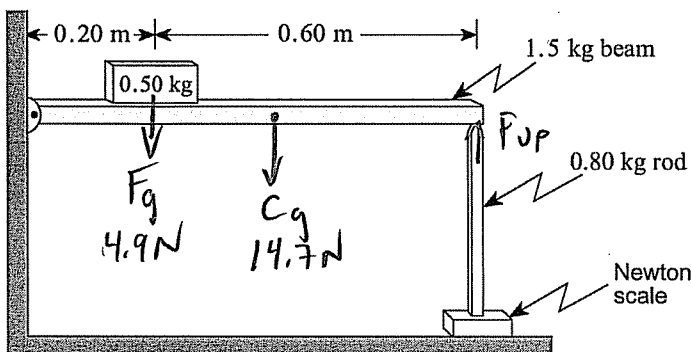What is the magnitude of the sum of the two forces shown in the diagram below?

Diagram labels: $F_1 = 85$ N, 150°, 30°, $F_2 = 57$ N

Handwritten: 85N, 30°, 57N
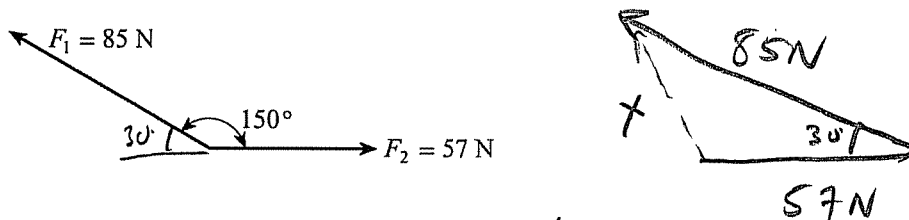
A. 46 N
B. 102 N
C. 137 N
D. 142 N

Handwritten:
$$x^2 = a^2 + b^2 - 2ab\cos C$$
$$= 85^2 + 57^2 - 2(85)(57)\cos 30°$$
$$= 45.6N$$

4.

A uniform 1.5 kg beam hinged at one end supports a 0.50 kg block. The beam is held level by a vertical 0.80 kg rod resting on a Newton scale at the other end.

What is the reading on the scale?

A. 8.6 N
B. 9.1 N
C. 16 N
D. 27 N

$\Sigma \tau = 0 \quad CW\tau = CCW\tau$

$(4.9N)(.2m) + (14.7N)(.4m) = F_{up}(.8m)$

$F_{up} = 8.6N$

$+ (.8)(9.8)$

$= 16N$

5.

A 35 kg traffic light is suspended from two cables as shown in the diagram.

$F_g = 35(9.8)$
$= 343N$
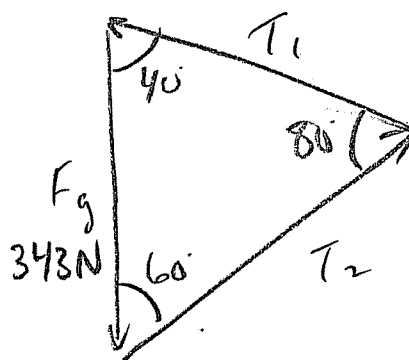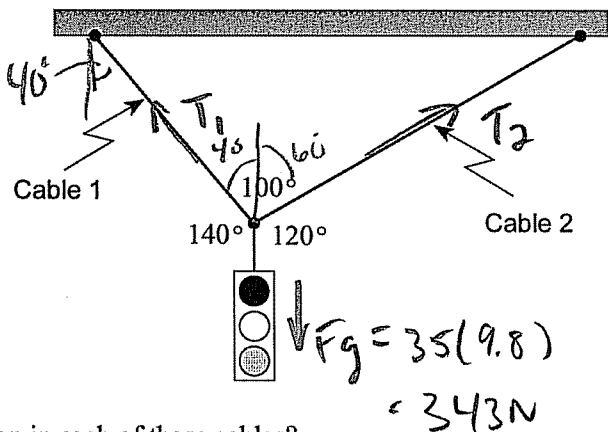
What is the tension in each of these cables?

6.

The unit for torque is

A. J
B. N·m
C. N·s
D. kg·m/s

$\frac{T_1}{\sin 60} = \frac{343N}{\sin 80} = \frac{T_2}{\sin 40}$

$T_1 = 302N, \quad T_2 = 224N$

7.

An 85 kg object is suspended from a ceiling and attached to a wall.

65°

T_2

70°
T_1
110°

Left-hand rope

85 kg (9.8)
$= 833N$

T_1 45°

110°

F_g 25°
833N T_2

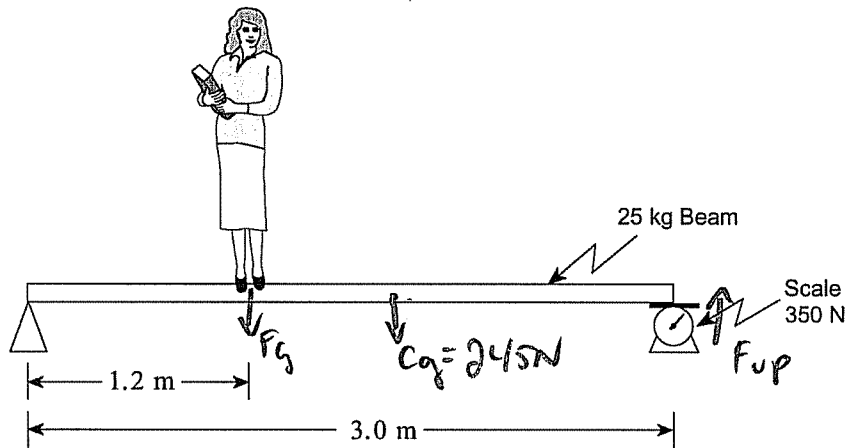$$\frac{833N}{\sin 45} = \frac{T_1}{\sin 25}$$

$$T_1 = 498N$$
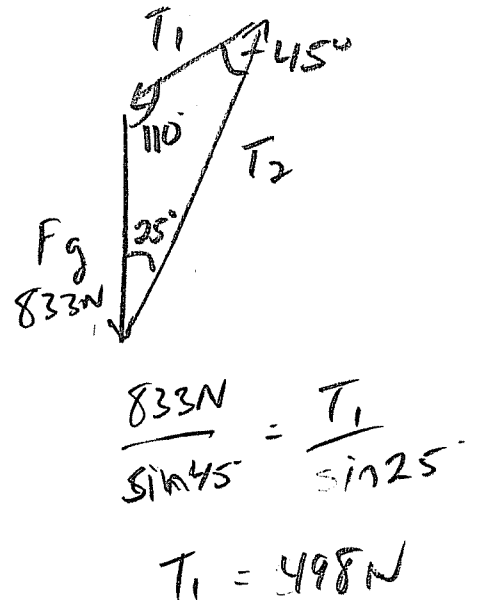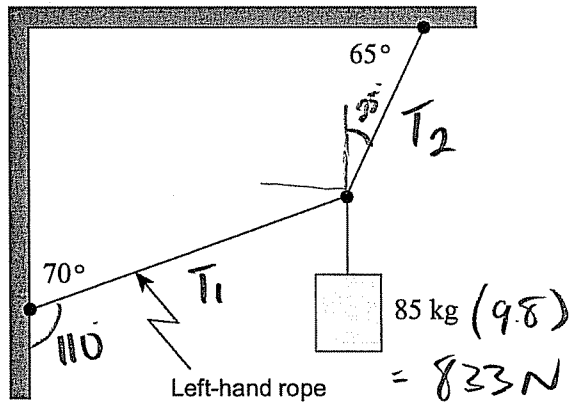
What is the tension in the left-hand rope?

A. 280 N
B. 350 N
C. 500 N
D. 1 100 N

8.

A student stands on a uniform 25 kg beam. The scale on the right end reads 350 N.

25 kg Beam

Scale
350 N

F_g

$C_g = 245N$

F_{up}

|← 1.2 m →|

|← 3.0 m →|

$\Sigma \tau = 0$ $CWT = CCWT$

$$F_g(1.2) + 245N(1.5) = (350N)(3m)$$

$$F_g = 569N$$

$$m = 58 kg$$

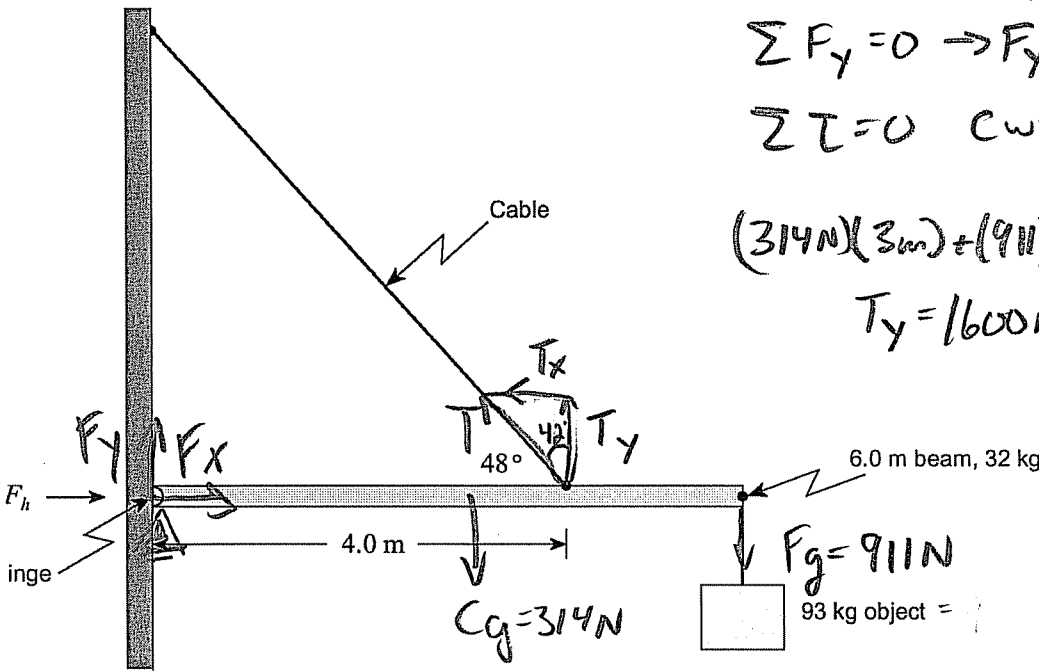What is the mass of the student?

A. 45 kg
B. 54 kg
C. 58 kg
D. 89 kg

9.

A body is in static equilibrium when

A. $\Sigma \tau = 0$ only.
B. $\Sigma F = 0$ only.
C. $\Sigma F = 0$ and $\Sigma \tau = 0$.
D. $\Sigma F = 0$ and $\Sigma \tau \neq 0$.

10.

A 6.0 m uniform beam of mass 32 kg is suspended horizontally by a hinged end and a cable. A 93 kg object is connected to one end of the beam.

$$\Sigma F_x = 0 \rightarrow F_x = T_x$$
$$\Sigma F_y = 0 \rightarrow F_y + T_y = C_g + F_g$$
$$\Sigma T = 0 \quad CWT = CCWT$$

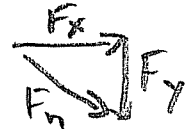$$(314N)(3m) + (911)(6m) = T_y \cdot 4m$$
$$T_y = 1600N, \quad \tan 42° = \frac{T_x}{T_y}$$

$$T_x = 1440N = F_x$$

$$F_y = 314 + 911 - 1600$$
$$\leftarrow -375N$$
downward force

Cable

T_x

T 42° T_y

48°

F_y | F_x

$F_h \rightarrow$

F_h

inge

4.0 m

$C_g = 314N$

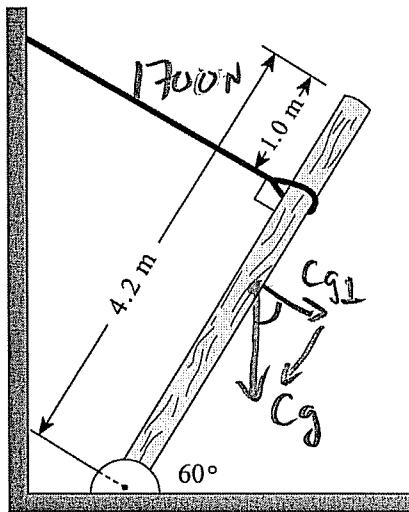6.0 m beam, 32 kg

$F_g = 911N$

93 kg object =

F_x
F_n F_y

$$1440^2 + 375^2 = x^2$$
$$F_h = 1490 N$$

What is the magnitude of the horizontal force F_h that the hinge exerts on the beam? (7 marks)

11.

A 4.2 m long uniform post is supported by a cable having a tension of 1 700 N. What is the mass of this post?

1700N

1.0 m

4.2 m

C_{g1}

C_g

60°

$$\Sigma T = 0 \quad CWT = CCWT$$

$$C_{g1}(2.1m) = 1700N(3.2m)$$
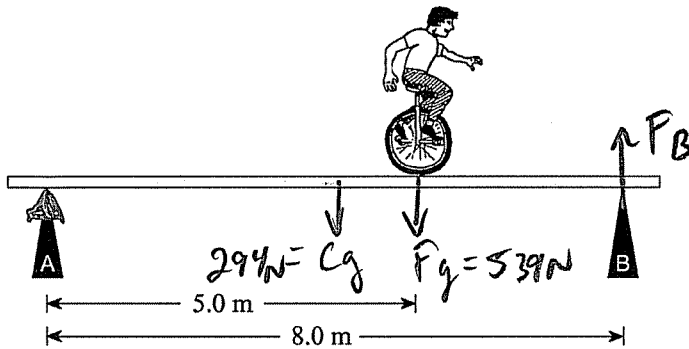
$$C_{g1} = 2600N$$

$$\cos 60 = \frac{2600}{C_g}$$

$$C_g = 5180 \div 9.8$$

$$m = 530 \, kg$$

A. 160 kg
B. 260 kg
C. 300 kg
D. 530 kg

12.

A circus performer on a unicycle of total mass 55 kg rides across a uniform 30 kg beam. The supports are placed equal distances from the ends of the beam.

$\sum F_y = 0 \rightarrow F_A + F_B = C_g + F_g$

$\sum \tau = 0 \quad CWT = CCWT$

$(294N)(4) + (539N)(5_A) = F_B(8_A)$

$F_B = 484N$

$F_A = 294 + 539 - 484N$

$= 349N$

a) When he is at the position shown, determine the forces exerted by the supports on the beam. **(5 marks)**

b) As the performer moves toward the right the force exerted by support B will

☐ remain the same.
☑ increase.
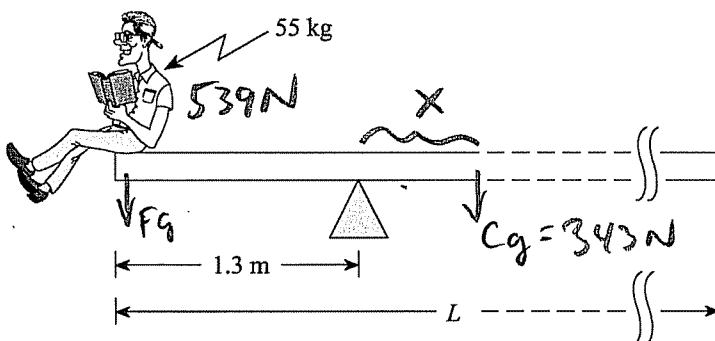☐ decrease.

(Check one response.) **(1 mark)**

13.

A body is in rotational equilibrium when

(A.) $\sum \tau = 0$
B. $\sum F = 0$
C. $\sum p = 0$
D. $\sum E_k = 0$

14.

A 35 kg uniform plank is balanced at one end by a 55 kg student as shown.

$\sum \tau = 0 \quad CWT = CCWT$

$(539N)(1.3m) = (343N) X$

$X = 2.0$

$2.0m + 1.3m = 3.3 m \left(\frac{1}{2} \text{ the length}\right)$

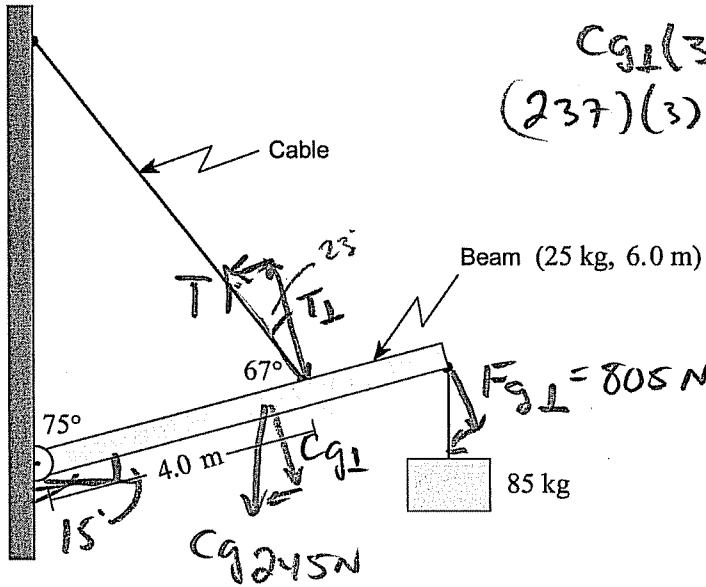$\ell = 6.6m$

What is the overall length of this plank?

A. 2.6 m
B. 3.3 m
C. 5.4 m
(D.) 6.7 m

15.

A 6.0 m uniform beam of mass 25 kg is suspended by a cable as shown. An 85 kg object hangs from one end.

$\Sigma \tau = 0 \quad Cw\tau = ccw\tau$

$Cg_{\perp}(3) + Fg_{\perp}(6) = T_{\perp}(4m)$

$(237)(3) + (805)(6) = T_{\perp}(4m)$

$T_{\perp} = 1385N$

$\cos 23° = \dfrac{T_{\perp}}{T} = \dfrac{1385N}{T}$

$T = 1500N$

Cable

Beam (25 kg, 6.0 m)

T 23° $T_{\perp}$

67°

$Fg_{\perp} = 805 N$

75°

$Cg_{\perp}$

4.0 m

85 kg

15°

Cg 245N

What is the tension in the cable?
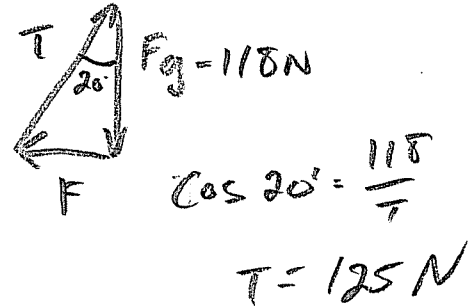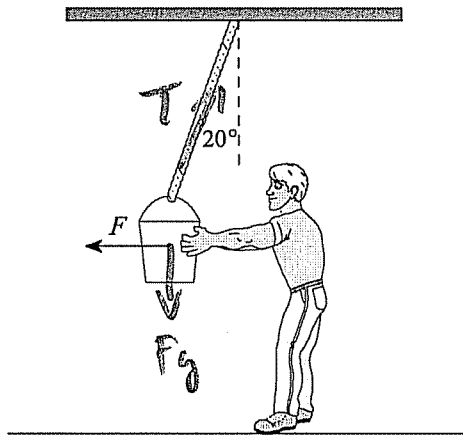
$Cg_{\perp} = Cg \cos 15°$
$= 237N$

(7 marks)

16.

Peter exerts a horizontal force F on a 12 kg bucket of concrete so that the supporting rope makes an angle of 20° with the vertical.

T 20°

F

F_g

T 20° $Fg = 118N$

F

$\cos 20° = \dfrac{118}{T}$

$T = 125N$

a) Find the tension force in the supporting rope. **(5 marks)**

b) Peter now exerts a new force which causes the rope to make a greater angle with the vertical. How will the tension force in the supporting rope change?
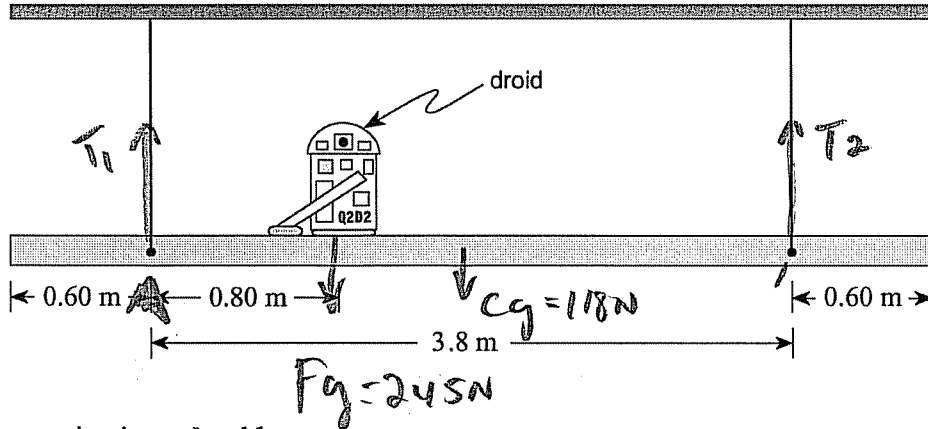
☑ The tension force will increase.

☐ The tension force will decrease.

☐ The tension force will remain the same.

(Check one response.) **(1 mark)**

17.

A 25 kg droid rests on a 5.0 m long shelf supported by two cables as shown. The mass of the shelf is 12 kg.

$\sum F_y = 0$ $T_1 + T_2 = F_g + C_g$

$\sum T = 0$ $cw\tau = ccw\tau$

$245N(.8) + 118(1.9) = T_2(3.8)$

$T_2 = 110 N$

$T_1 = 245N + 118N - 110N$

$= 253 N$

droid

T_1 T_2

0.60 m   0.80 m $C_g = 118N$ 0.60 m

3.8 m

$F_g = 245N$

Find the tension in **each** cable.   (7 marks)

Answers:
1. A
2. a
3. a
4. c
5. T_1=302 N, T_2=224 N
6. b
7. c
8. c
9. c
10. F_h=1.4 x 10^3 N
11. d
12. a) F_B=480 N, F_A=350 N
    b) increase
13. a
14. d
15. 1500 N
16. a) 1.3 x 10^2 N b) increase
    c) The vertical component of the tension is equal weight and is unchanged. Peter's horizontal force increases with a larger angle. The horizontal component of the tension is equal to Peter's and therefore also increases. Thus, the resultant tension is increased.
17. T_L=253 N, T_R=110 N