3. EQUILIBRIUM (~7%)

• 29 Multiple Choice Questions

• 14 Long Answer Problems

Answers:

Multiple Choice

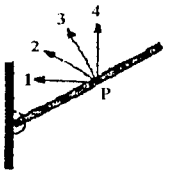
1. c	11.a	21.c
2. c	12.c	22.c
3. d	13.a	23.c
4. a	14.c	24.c
5. a	15.c	25.c
6. d	16.a	26.b
7. a	17.b	27.a
8. c	18.d	28.b
9. b	19.a	29.b
10.d	20.d	

Long Answers

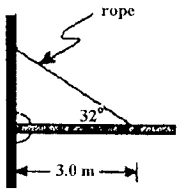
1. T_l= 252 N
   T_r= 110 N
2. b) 954 kg
3. a) 0.313 m
   b) 19.1 N
4. a) 19.9 kg
5. a) 125 N
   b)Increase
   c)Hypotenuse
6. a) 65 kg
7. a)
   b) 36.6 N
8. a)
   b) 283 N
   c) 438 N
   d) 0.645
9. 1.50×10^3 N
10. a) 91.4 N
    b) 18.4 kg
11. a) 449 N
    b) 368 N
12. a)
    b) 93.3 kg
13. F_l= 299 N
    F_r= 593 N
14. a)
    b) 3.81×10^2 N

Multiple Choice:

1. In which direction should a force act at point P to hold the boom in equilibrium so that the force will be a minimum?



A. 1
B. 2
C. 3
D. 4

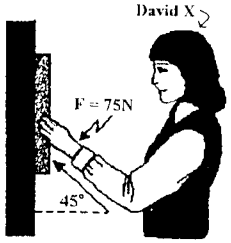


2. A uniform 16.0 kg boom of length 4.0 m is supported by a rope as shown.

Find the tension in the rope.

A. 1.0×10^2 N
B. 1.2×10^2 N
C. 2.0×10^2 N
D. 3.0×10^2 N

3. An artist must push with a minimum force of 75 N at an angle of 45° to a picture to hold it in equilibrium. The coefficient of friction between the wall and the picture frame is 0.30. What is the mass of the picture?

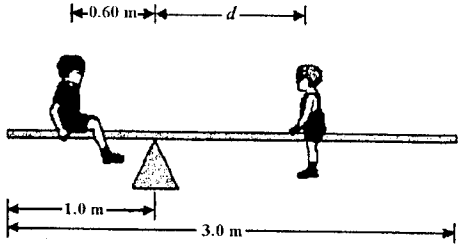


A. 1.6 kg
B. 2.3 kg
C. 3.8 kg
D. 7.0 kg

4. Two forces, 12 N west and 5.0 N north, act on an object. What is the direction of a third force that would produce static equilibrium?

A. 23° south of east B. 23° north of west C. 67° south of east D. 67° north of west

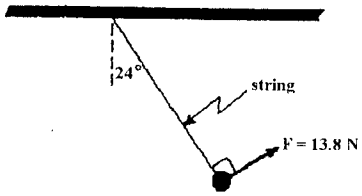
5. A 3.0 m uniform beam of mass 15 kg is pivoted 1.0 m from the end as shown below.



A 35 kg child sits 0.60 m from the pivot. How far, *d*, from the pivot, must a 20 kg child sit in order for the beam to be in equilibrium?

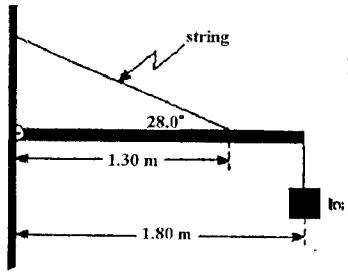
A. 0.68 m B. 1.0 m C. 1.1 m D. 1.4 m

6. A mass suspended by a string is held 24° from vertical by a force of 13.8 N as shown. Find the mass.



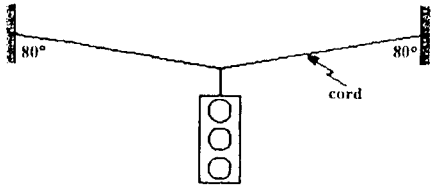
A. 0.57 kg
B. 1.5 kg
C. 3.2 kg
D. 3.5 kg

7. The diagram shows a horizontal beam of negligible mass. The wall exerts a 42.0 N horizontal force on the lever. Find the weight of the load.



A. 16.1 N
B. 22.3 N
C. 34.4 N
D. 47.6 N

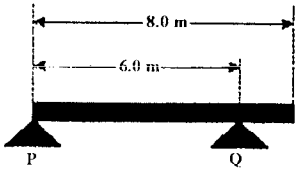
8. A 75 kg traffic light is held stationary midway between two supports, as shown in the diagram below.



What is the tension in the cord?

A. 3.7×10^2 N
B. 7.4×10^2 N
C. 2.1×10^3 N
D. 4.2×10^3 N

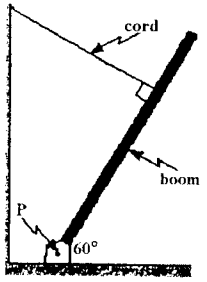
9. A uniform beam of mass 25 kg rests on supports P and Q, as shown in the diagram below.



What force is exerted by support Q on the beam?

A. 1.2×10^2 N
B. 1.6×10^2 N
C. 3.3×10^2 N
D. 4.9×10^2 N

10. A boom hinged at P is held stationary, as shown in the diagram below.



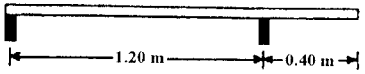
If the tension in the supporting cord, attached three-quarters of the way along the boom from P, is 720 N, what is the weight of the boom?

A. 720 N
B. 1 080 N
C. 1 440 N
D. 2 160 N

11. What are the units of torque?

A. N·m B. N/m C. N·s D. N/s

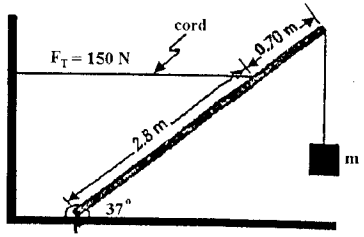
12. A uniform 1.60 m board rests on two bricks as shown below. The left brick exerts an upward force of 12 N on the board.



What upward force does the right brick exert?

A. 3.0 N B. 12 N C. 24 N D. 36 N

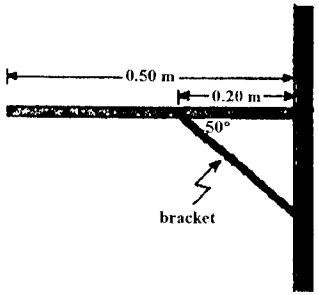
13. A uniform 3.5 m beam of negligible mass, hinged at P, supports a hanging block as shown.



If the tension F_T in the horizontal cord is 150 N, what is the mass of the hanging block?

A. 9.2 kg
B. 12 kg
C. 16 kg
D. 46 kg

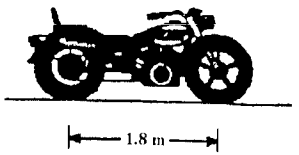
14. A uniform 3.0 kg shelf of width 0.50 m is supported by a bracket, as shown in the diagram to the left.



What force does the bracket exert on the shelf?

A. 7.4 N
B. 38 N
C. 48 N
D. 57 N

15. The motorcycle shown has a mass of 200 kg and a wheel base of 1.8 m.



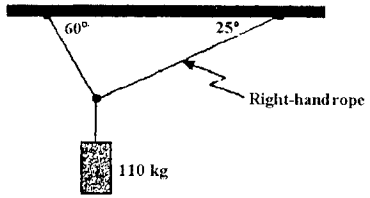
If the rear wheel exerts a 1 200 N force on the ground, find how far the motorcycle's centre of gravity is located from the front wheel.

A. 0.70 m
B. 0.90 m
C. 1.1 m
D. 1.2 m

16. A body is in rotational equilibrium when

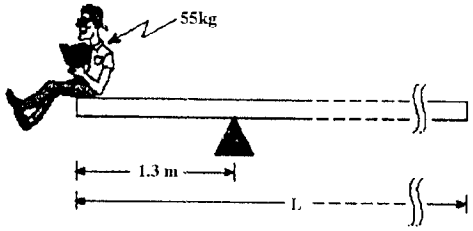
A. $\Sigma\tau = 0$ B. $\Sigma F = 0$ C. $\Sigma p = 0$ D. $\Sigma E_k = 0$

17. A 110 kg object is supported by two ropes attached to the ceiling. What is the tension T in the right-hand rope?



A. 460 N
B. 540 N
C. 930 N
D. 1 300 N

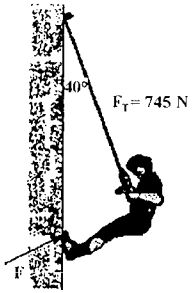
18. A 35 kg uniform plank is balanced at one end by a 55 kg student as shown.



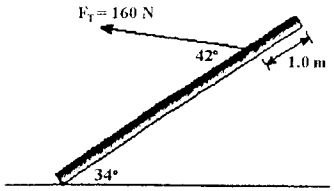
What is the overall length of this plank?
A. 2.6 m
B. 3.3 m
C. 5.4 m
D. 6.7 m

19. State the condition for **translational** equilibrium.
A. $\Sigma F = 0$ B. $\Sigma F \neq 0$ C. $\Sigma \tau = 0$ D. $\Sigma \tau \neq 0$

20. An 85.0 kg mountaineer remains in equilibrium while climbing a vertical cliff. The tension force in the supporting rope is 745 N.

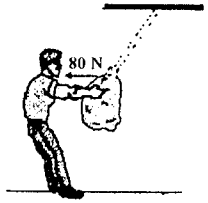


Find the magnitude of the reaction force, F, which the cliff exerts on the mountaineer's feet.
A. 88.0 N
B. 373 N
C. 479 N
D. 546 N

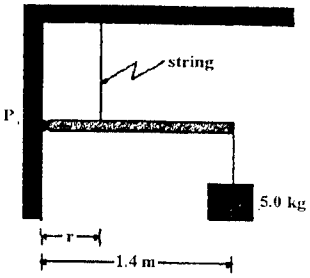


21. A uniform 15 kg pipe of length 5.0 m has a 160 N force applied 4.0 m from its lower end as shown.
Using the point where the pipe touches the ground as a pivot, calculate the sum of the torques acting on the pipe.
A. 180 N· m in a clockwise direction.
B. 270 N· m in a clockwise direction.
C. 120 N· m in a counter-clockwise direction.
D. 270 N· m in a counter-clockwise direction.

22. A 220 N bag of potatoes is suspended from a rope as shown in the diagram. A person pulls horizontally on the bag with a force of 80 N.
What is the tension in the rope?
A. 1.4×10^2 N
B. 2.2×10^2 N
C. 2.3×10^2 N
D. 3.0×10^2 N

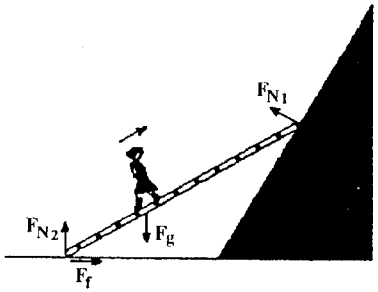


23. A uniform 18 kg beam hinged at P is held horizontal by a vertical string that can withstand a maximum tension of 350 N. A 5.0 kg mass is suspended from the end of the beam as shown.



At what minimum distance, x, can the string be attached without breaking?
A. 0.16 m
B. 0.20 m
C. 0.55 m
D. 0.70 m

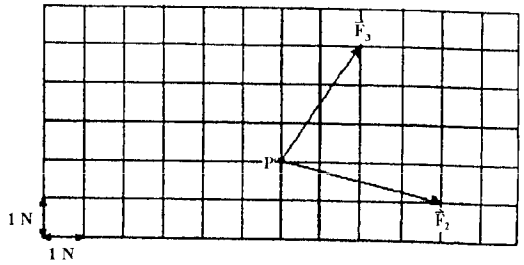
24. The diagram shows the forces acting on a massless ladder resting on the floor and a frictionless slope.



As a person walks up the stationary ladder, what happens to the magnitude of the forces F_{N1} and F_{N2}?

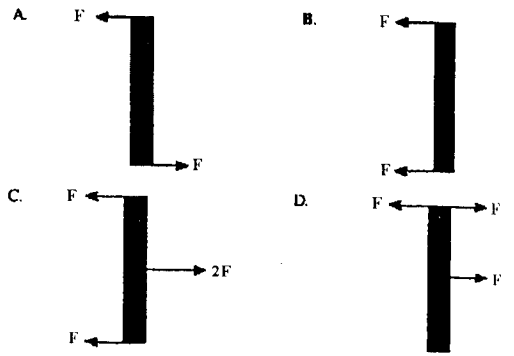
	MAGNITUDE OF F_{N1}	MAGNITUDE OF F_{N2}
A.	Decrease	Decrease
B.	Decrease	Increase
C.	Increase	Decrease
D.	Increase	Increase

25. Two forces act at point P as shown below.

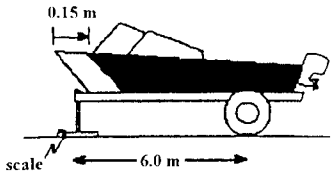


Find the magnitude of the third force required to achieve equilibrium.
A. 4.5 N
B. 5.5 N
C. 6.3 N
D. 7.2 N

26. Which of the following shows a uniform beam which is in rotational equilibrium but **not** translational equilibrium?

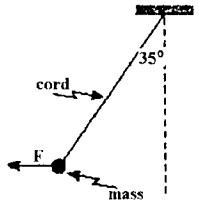


27. A trailer carrying a boat is supported by a scale which initially reads 48 kg. The boat (and therefore its centre of gravity) is moved 0.15 m further back on the trailer. The scale now reads 37 kg. Find the mass of the boat.



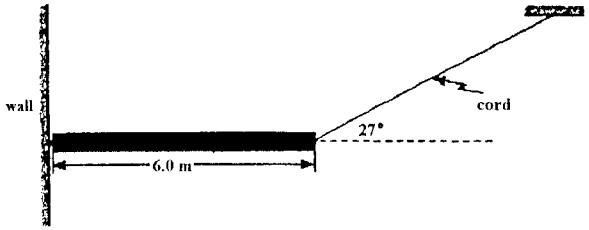
A. 440 kg
B. 1 600 kg
C. 1 700 kg
D. 3 400 kg

28. A mass of 5.0 kg is suspended from a cord as shown in the diagram below. What horizontal force F is necessary to hold the mass in the position shown?

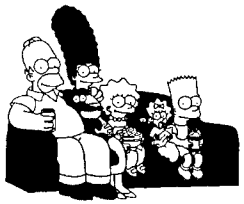


A. 28 N
B. 34 N
C. 40 N
D. 70 N

29. A uniform 25 kg bar, 6.0 m long, is suspended by a cord as shown.

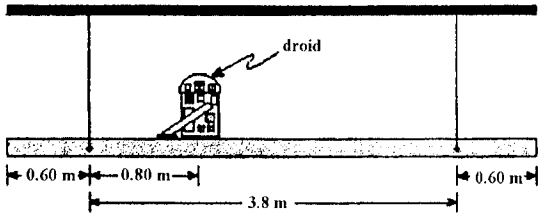


What is the tension in the cord?
A. 1.2×10^2 N
B. 2.7×10^2 N
C. 3.7×10^2 N
D. 5.4×10^2 N



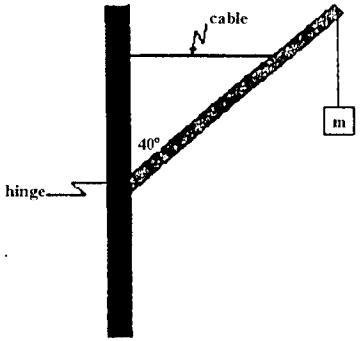
Written Problems:

1. 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.



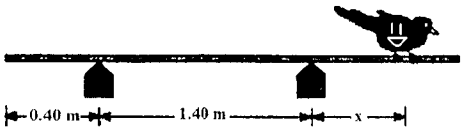
Find the tension in **each cable. (7 marks)**

2. A uniform 350 kg beam of length 4.2 m is held stationary by a horizontal cable. The cable is attached to a point on the beam 3.0 m from the hinge.



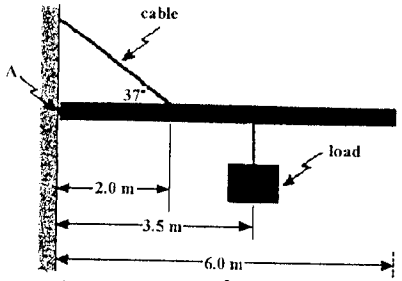
a) Draw and label a free body diagram showing the forces on the beam. **(2 marks)**
b) If the maximum tension the cable can withstand is 1.3×10^4 N, what maximum mass, *m*, can be suspended from the end of the beam? **(5 marks)**

3. A 0.75 kg board of length 2.60 m initially rests on two supports as shown.



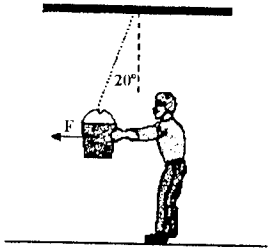
a) What maximum distance, *x*, from the right-hand support can a 1.20 kg bird walk before the board begins to leave the left-hand support? **(5 marks)**
b) What force does the right-hand support exert on the board at that instant? **(2 marks)**

4. A uniform beam 6.0 m long, and with a mass of 75 kg, is hinged at A. The supporting cable keeps the beam horizontal.



If the maximum tension the cable can withstand is 2.4×10^3 N, what is the maximum mass of the load? **(7 marks)**

5. 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.

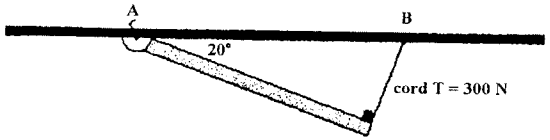


a) Find the tension force in the supporting rope. **(5 marks)**
b) Peter now exerts a new force which causes the rope to make a greater angle with the vertical. How will the tension force in the supporting rope change?

- ☐ The Tension force will Increase
- ☐ The Tension force will decrease
- ☐ The Tension force will remain constant

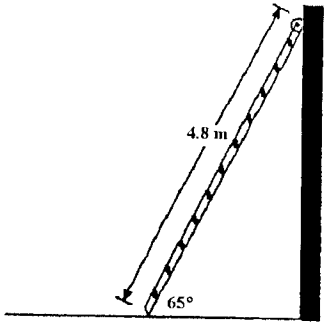
(Check one response.) **(1 mark)**
c) Using principles of physics, explain your answer to b). **(3 marks)**

6. A 3.8 m uniform beam is attached to the ceiling with a hinge at A and a cord with a tension of 300 N at B.



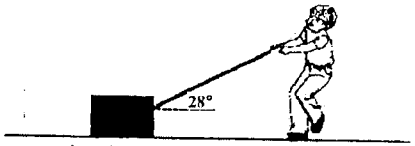
Determine the mass of the beam. **(7 marks)**

7. A uniform 4.8 m long ladder of mass 16 kg leans against a frictionless vertical wall as shown in the diagram below.



a) Draw and label a free body diagram showing the forces acting on the ladder. **(2 marks)**
b) What minimum force of friction is needed at the base of the ladder to keep it from sliding? **(5 marks)**

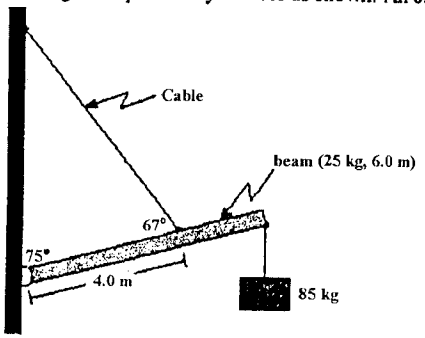
8. A 60 kg block rests on the ground. A student exerts a 320 N force on the block by pulling on a rope, but friction prevents the block from moving.



a) Draw and label a free body diagram showing all forces acting on the block. **(2 marks)**
b) Calculate the force of friction on the block. **(2 marks)**
c) Calculate the normal force exerted by the ground on the block. **(2 marks)**

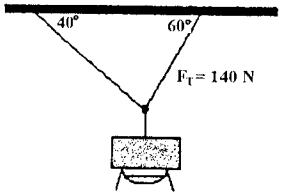
d) Calculate the minimum coefficient of friction between the block and the ground. **(1 mark)**

9. 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.



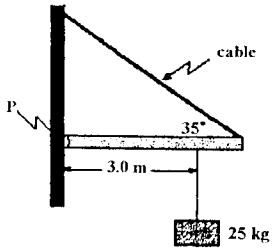
What is the tension in the cable? **(7 marks)**

10. A floodlight is suspended from two cables as shown below. The tension in the right cable is 140 N.



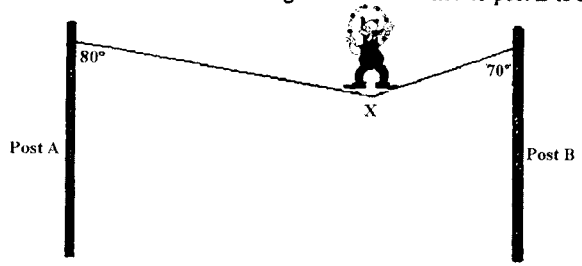
a) What is the tension in the left cable? **(3 marks)**
b) What is the mass of the floodlight? **(4 marks)**

11. A uniform 15 kg beam of length 4.0 m is supported against a wall as shown in the diagram. A 25 kg object is suspended 3.0 m from the hinge P.



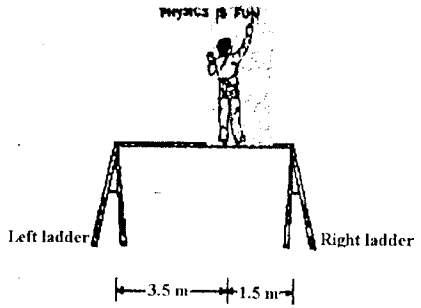
a) What is the tension in the support cable? **(5 marks)**
b) What is the magnitude of the horizontal component of the reaction force of the wall on the beam at the hinge P? **(2 marks)**

12. A circus performer walks across a wire stretched between two vertical posts. When the performer stands at position X as shown below, the tension in the short length of wire attached to post B is 1.8×10^3 N.

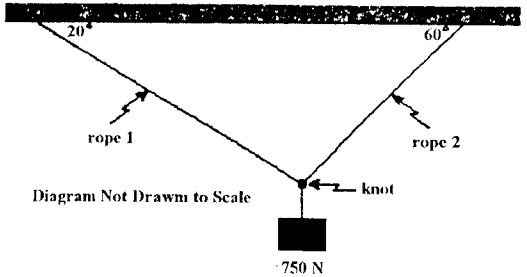


a) Draw and label a free body diagram showing the forces acting at position X. **(2 marks)**
b) What is the mass of the circus performer? **(5 marks)**

13. A 75 kg painter stands on a uniform 5.0 m board of mass 16 kg supported horizontally by two ladders. Find the forces exerted by each ladder on the board. **(7 marks)**



14. A 750 N weight is supported by two ropes fastened together by a knot, as shown in the diagram below.



a) Draw a free-body diagram showing the forces acting on the knot. **(2 marks)**
b) What is the tension in rope 1? **(5 marks)**