

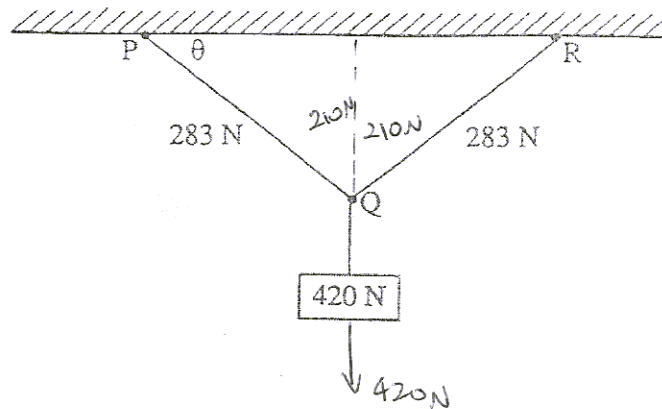
# Dynamics & Equilibrium

# Dynamics - the Study of Forces

3. The following diagram (not drawn to scale) shows a 420 N object suspended by two wires.

6/93

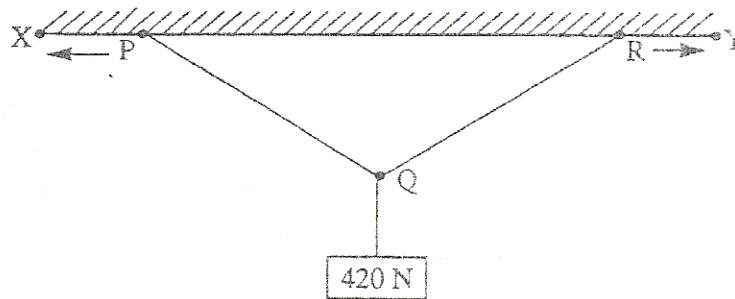
#1



- (a) If the force in each wire is 283 N, what is angle  $\theta$ ?

$$\sin \theta = \frac{210 \text{ N}}{283 \text{ N}} \quad \theta = \sin^{-1}\left(\frac{210}{283}\right) = 48^\circ$$

- (b) The points of attachment R and P are now moved outwards to points Y and X respectively, as shown below.



- i) Does the tension in PQ increase, decrease, or stay the same?

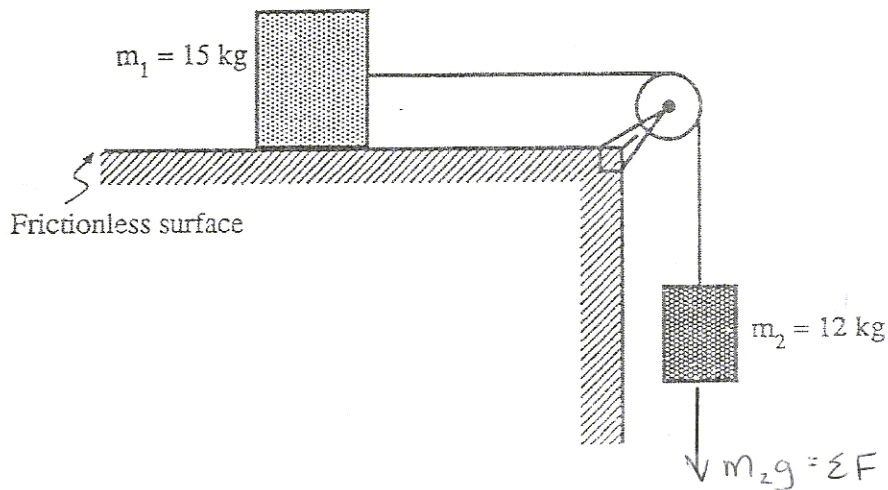
Increase

- ii) Using the conditions for equilibrium, give supporting reasons for your choice in (b i).  
In order for the object to remain at equilibrium, string PQ must exert a tension whose vertical component equals to half of 420 N (the other half is provided by string QR).

As string PQ slides to the new position XQ,  $\theta$  decreases, while the vertical component of tension remains the same. The total tension of XQ is given by the expression  $\sin \theta = \frac{T_y}{T}$ , or  $T = \frac{T_y}{\sin \theta}$ .

As  $\theta$  decreases,  $\sin \theta$  decreases and therefore T increases.

- 6/93  
#2
1. Two objects are connected together by a light string over a frictionless pulley, as shown below. Object  $m_1$  has a mass of 15 kg and the hanging object  $m_2$  has a mass of 12 kg.



- a) What is the magnitude of the acceleration of the object  $m_1$ ?

$$a = \frac{\Sigma F}{m} = \frac{m_2 g}{m_1 + m_2} = \frac{(12 \text{ kg})(9.8 \text{ m/s}^2)}{15 \text{ kg} + 12 \text{ kg}} = 4.4 \text{ m/s}^2$$

- b) What is the tension in the connecting string?

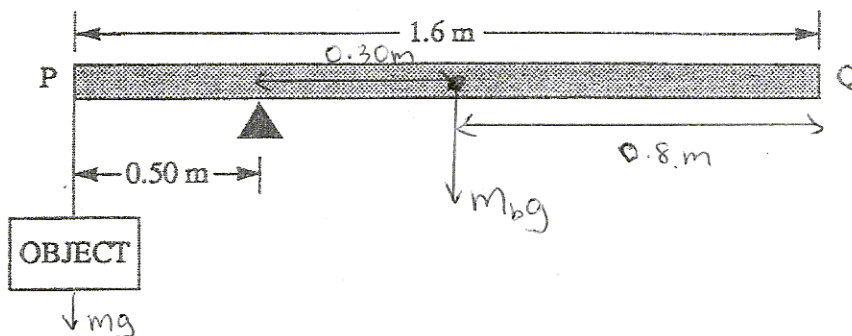
$$\Sigma F = m_2 a$$

$$T = m_2 (g - a)$$

$$m_2 g - T = m_2 a$$

$$= 12 \text{ kg} (9.8 \text{ m/s}^2 - 4.4 \text{ m/s}^2) = 65 \text{ N}$$

- 6/93  
#3
10. A uniform beam has a mass of 3.5 kg. Its length is 1.6 m and a pivot is placed 0.50 m from end P, as shown in the diagram below. The beam is balanced by suspending an object at P.



What is the mass of the object?

- A. 1.1 kg  
B. 2.1 kg  
C. 5.8 kg  
D. 7.7 kg

$$\Sigma \tau = 0$$

$$\tau_c = \tau_{cc}$$

$$F_c d_1 = F_{cc} d_2$$

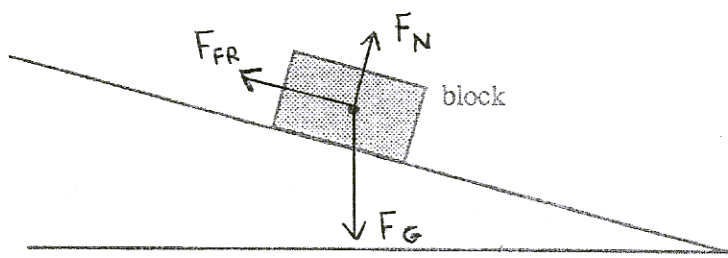
$$m_b g d_1 = m g d_2$$

$$(3.5 \text{ kg})(0.30 \text{ m}) = m(0.50 \text{ m})$$

$$m = 2.1 \text{ kg} \quad \boxed{B}$$

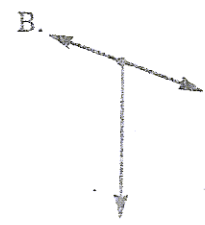
6/93  
 4. As shown in the diagram below, a block on an inclined plane is at rest due to friction.

#4



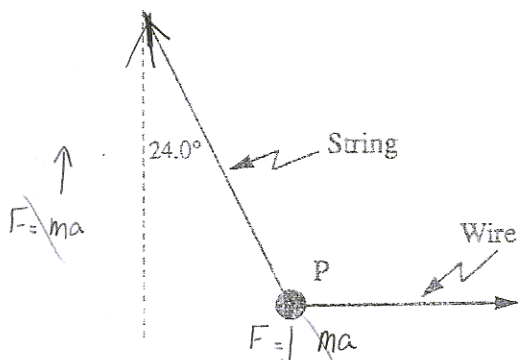
Which one of the following best shows the forces on the block?

DIAGRAMS NOT DRAWN TO SCALE



9. A 4.60 kg mass P is held in equilibrium by a pendulum string, a horizontal wire, and gravity.

6/93  
 #5



$$F = ma$$

$$F = (4.60)(9.80)$$

$$F = 45.08 \text{ N}$$

What is the tension in the pendulum string?

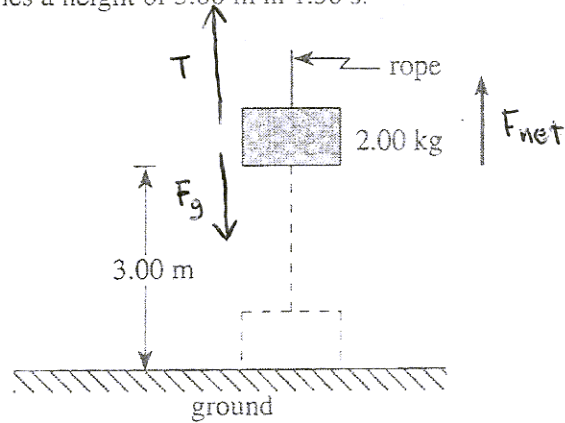
- A. 5.03 N
- B. 41.2 N
- C. 49.3 N
- D. 111 N

$$\cos 24^\circ = \frac{45.08}{x} \Rightarrow 0.91 = \frac{45.08}{x}$$

&  $x = \boxed{49.3 \text{ N}}$

- 1/94 5. A 2.00 kg object, initially at rest on the ground, is accelerated vertically by a rope, as shown. The object reaches a height of 3.00 m in 1.50 s.

#6



What is the tension in the rope during the acceleration?

- A. 5.33 N
- B. 14.3 N
- C. 23.6 N
- D. 24.9 N

$$d_y = 3.00 \text{ m}$$

$$t = 1.50 \text{ s}$$

$$v_{y0} = 0 \text{ m/s}$$

$$a = ?$$

$$d_{y0} = v_{y0} t + \frac{1}{2} a t^2$$

$$3.00 \text{ m} = (0 \text{ m/s})(1.50 \text{ s}) + \frac{1}{2} (a)(1.50 \text{ s})^2$$

$$(2)(3.00 \text{ m}) = (a)(2.25 \text{ s}^2)$$

$$a = 2.67 \text{ m/s}^2$$

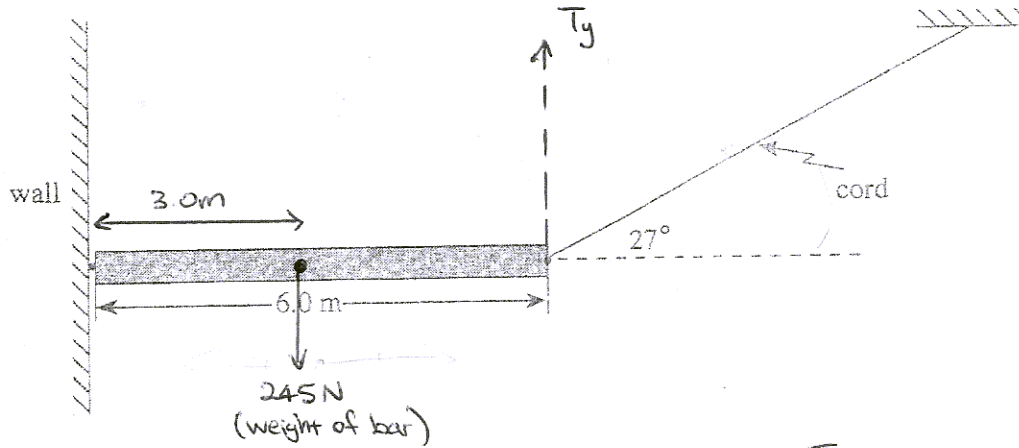
$$F_{\text{net}} = ma = 2.00 \text{ kg} \cdot 2.67 \text{ m/s}^2 = 5.34 \text{ N}$$

$$F_{\text{net}} = T - F_g$$

$$T = F_{\text{net}} + F_g = F_{\text{net}} + mg = 5.34 \text{ N} + (2.00 \text{ kg})(9.8 \text{ m/s}^2) = 24.9 \text{ N}$$

1/94 8. A uniform 25 kg bar, 6.0 m long, is suspended by a cord as shown.

#7



What is the tension in the cord?

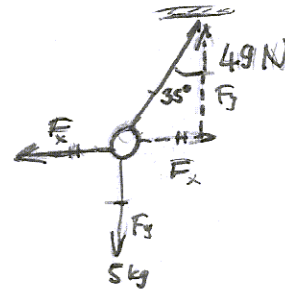
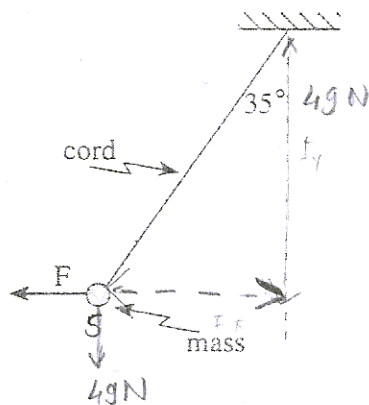
- A.  $1.2 \times 10^2$  N
- B.  $2.7 \times 10^2$  N
- C.  $3.7 \times 10^2$  N
- D.  $5.4 \times 10^2$  N

$\sum \tau = 0$   
 $\tau_c = \tau_{cc}$   
 $F_1 d_1 = F_2 d_2$   
 $W d_1 = T_y d_2$   
 $(245 \text{ N})(3.0 \text{ m}) = T_y (6.0 \text{ m})$   
 $T_y = 122.5 \text{ N}$

$\sin 27^\circ = \frac{T_y}{T}$   
 $T = \frac{T_y}{\sin 27^\circ}$   
 $= \frac{122.5 \text{ N}}{\sin 27^\circ}$   
 $= 2.7 \times 10^2 \text{ N}$  B

1/94 7. 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?

#8



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

$F_y = 5 \text{ kg} \cdot 9.8 \text{ m/s}^2 = 49 \text{ N}$   
 $\tan 35^\circ = \frac{F_x}{49}$   
 $F_x = 49 \tan 35^\circ = 34 \text{ N}$

1/94 2. Unless acted on by an external net force, an object will stay at rest or

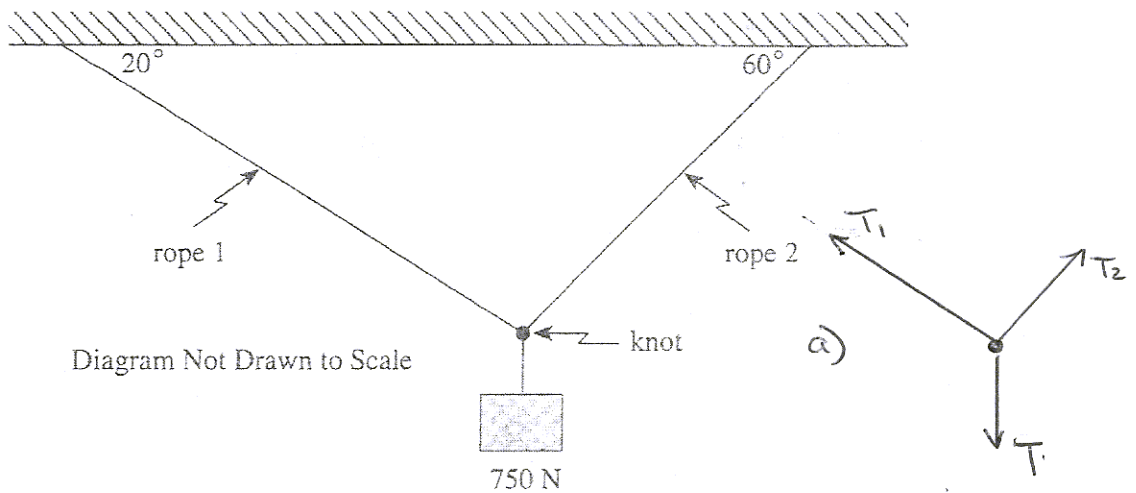
- A. come to rest.
- B. decelerate at a constant rate.
- C. slow down from a given speed.
- D. continue to move in a straight line at a constant speed.

#9

Newton's 1<sup>st</sup> Law (Inertia)

- 1/94 3. A 750 N weight is supported by two ropes fastened together by a knot, as shown in the diagram below.

#10

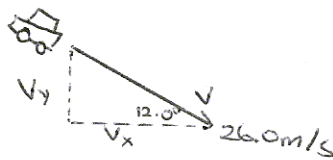


- a) Draw a free-body diagram showing the forces acting on the knot. (2 marks)
- b) What is the tension in rope 1? (5 marks)
- See bottom of page.

- 1/94 3. A car is travelling at a constant speed of 26.0 m/s down a slope which is  $12.0^\circ$  to the horizontal. What is the vertical component of the car's velocity?

#11

- A. 5.41 m/s  
 B. 9.80 m/s  
 C. 25.4 m/s  
 D. 26.0 m/s



$$\sin 12.0^\circ = \frac{v_y}{v}$$

$$v_y = v \sin 12.0^\circ$$

$$= (26.0 \text{ m/s}) \sin 12.0^\circ$$

$$= 5.41 \text{ m/s}$$

- 1/94 4. A 65.0 kg block is being accelerated along a level surface. The applied force is 500 N and the friction force is 300 N. What is the coefficient of friction between the block and the surface?

#12

- A. 0.31  
 B. 0.47  
 C. 0.78  
 D. 1.30

$$F_f = \mu F_n$$

$$F_f = \mu mg$$

$$\mu = \frac{F_f}{mg} = \frac{300 \text{ N}}{(65.0 \text{ kg})(9.8 \text{ m/s}^2)} = 0.47$$

10. b)  $T_{1x} = T_{2x}$

$$T_1 \cos 20^\circ = T_2 \cos 60^\circ$$

$$T_2 = \frac{T_1 \cos 20^\circ}{\cos 60^\circ}$$

$$T_{1y} + T_{2y} = 750 \text{ N}$$

$$T_1 \sin 20^\circ + T_2 \sin 60^\circ = 750 \text{ N}$$

$$T_1 \sin 20^\circ + \frac{T_1 \cos 20^\circ \sin 60^\circ}{\cos 60^\circ} = 750 \text{ N}$$

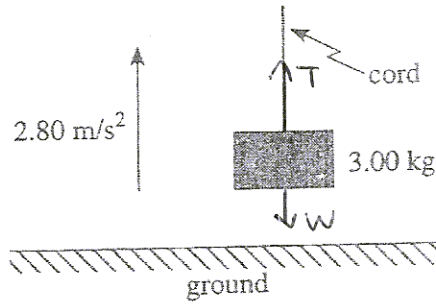
$$T_1 \left( \sin 20^\circ + \frac{\cos 20^\circ \sin 60^\circ}{\cos 60^\circ} \right) = 750 \text{ N}$$

$$T_1 = 381 \text{ N}$$

2. A 3.00 kg object is being accelerated vertically upwards at  $2.80 \text{ m/s}^2$ , as shown.

6/94

#13



What is the tension in the cord?

- A. 8.40 N  
B. 21.0 N  
C. 29.4 N  
D. 37.8 N

$$\Sigma F = ma$$

$$T - W = ma$$

$$T - mg = ma$$

$$T = mg + ma = m(g + a)$$

$$T = (3.00 \text{ kg})(9.8 \text{ m/s}^2 + 2.80 \text{ m/s}^2)$$

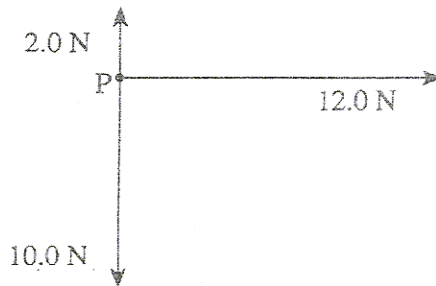
$$= 37.8 \text{ N}$$

D

3. Three forces act at point P at the same time, as shown on the force vector diagram below.

6/94

#14



What is the magnitude of the resultant force vector?

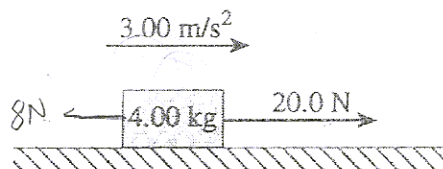
- A. 14.4 N  
B. 17.0 N  
C. 20.0 N  
D. 24.0 N

$$\sqrt{(10.0 \text{ N} - 2.0 \text{ N})^2 + 12.0 \text{ N}^2} = 14.4$$

4. A 4.00 kg block is accelerated along a level surface at  $3.00 \text{ m/s}^2$ . The applied force is 20.0 N.

6/94

#15



$$\frac{20 \text{ N}}{4 \text{ kg}} = 5 \text{ m/s}^2 \text{ (max a no fric)}$$

What is the coefficient of friction between the block and the surface?

- A. 0.20  
B. 0.31  
C. 0.51  
D. 0.67

$$W = F_{N_g} = F_g = 4.00 \text{ kg} \cdot 9.80 \text{ m/s}^2 = 39.2 \text{ N}$$

$$F_a = 3.00 \text{ m/s}^2 \cdot 4.00 \text{ kg} = 12.0 \text{ N}$$

$$F_f = 20.0 \text{ N} - F_a = 20 - 12 = 8.0 \text{ N}$$

$$F_a = \mu F_N$$

$$\mu = \frac{F_a}{F_N} = \frac{18.0 \text{ N}}{39.2 \text{ N}} = 0.20$$

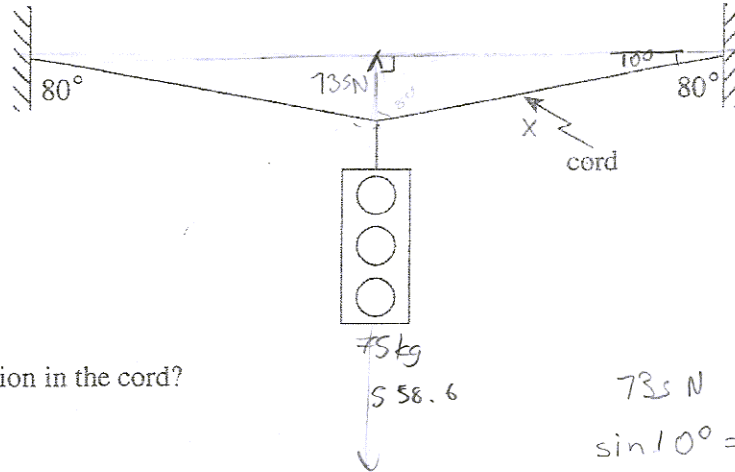
$$20 = \mu(4 \cdot 9.8)$$



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

6/94

#16



What is the tension in the cord?

- A.  $3.7 \times 10^2 \text{ N}$
- B.  $7.4 \times 10^2 \text{ N}$
- C.  $2.1 \times 10^3 \text{ N}$
- D.  $4.2 \times 10^3 \text{ N}$

$$735 \text{ N}$$

$$\sin 10^\circ = \frac{735 \text{ N}}{x}$$

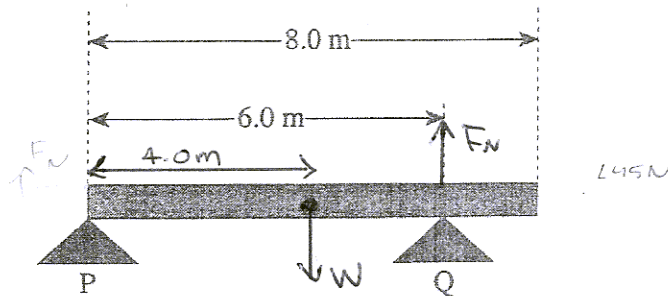
$$x = \frac{735}{\sin 10^\circ} = 4.2 \times 10^3 \text{ N}$$

$$= 2.1 \times 10^3 \text{ N} \quad \underline{\underline{2}}$$

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

6/94

#17



What force is exerted by support Q on the beam?

- A.  $1.2 \times 10^2 \text{ N}$
- B.  $1.6 \times 10^2 \text{ N}$
- C.  $3.3 \times 10^2 \text{ N}$
- D.  $4.9 \times 10^2 \text{ N}$

$$\sum \tau = 0$$

$$\tau_c = \tau_{cc}$$

$$F_1 d_1 = F_2 d_2$$

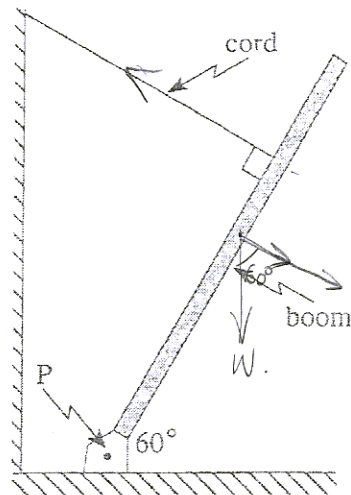
$$W d_1 = F_N d_2$$

$$(25 \text{ kg})(9.8 \text{ m/s}^2)(4.0 \text{ m}) = F_N (6.0 \text{ m})$$

$$F_N = 1.6 \times 10^2 \text{ N} \quad \boxed{\text{B}}$$

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

6/94  
#18



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**

$$\sum \tau$$

$$T\left(\frac{3}{4}\right) = W \cos 60 \left(\frac{1}{2}\right)$$

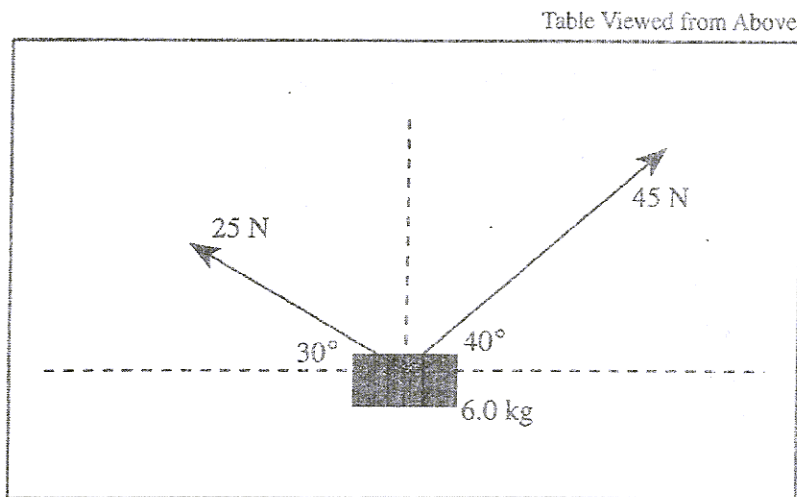
$$720\left(\frac{3}{4}\right) = \frac{W \cos 60}{2}$$

$$2(540) = W \cos 60$$

$$W = 2160 \text{ N}$$

1. A 6.0 kg block is held at rest on a horizontal, frictionless air table. Two forces are pulling on this block in the directions shown in the diagram below.

6/94  
#19



What will be the magnitude of the acceleration on the 6.0 kg block at the moment it is released?

$$25 \sin 30 \uparrow \quad 45 \sin 40 \uparrow$$

$$25 \cos 30 \leftarrow \quad 45 \cos 40 \rightarrow$$

$$\text{Total Upward force} = (45 \sin 40) + (25 \sin 30) = 41.43 \text{ N}$$

$$\text{Total Horizontal force} = (45 \cos 40) - (25 \cos 30) = 12.82 \text{ N}$$

$$\text{Resultant force} = \sqrt{(\text{Total } \uparrow F)^2 + (\text{Total } \leftrightarrow F)^2} = 43.36 \text{ N}$$

$$F = ma$$

$$43.36 = 6a$$

$$a = 7.23 \text{ m/s}^2$$

$$\tan \theta = \frac{41.43}{12.82}$$

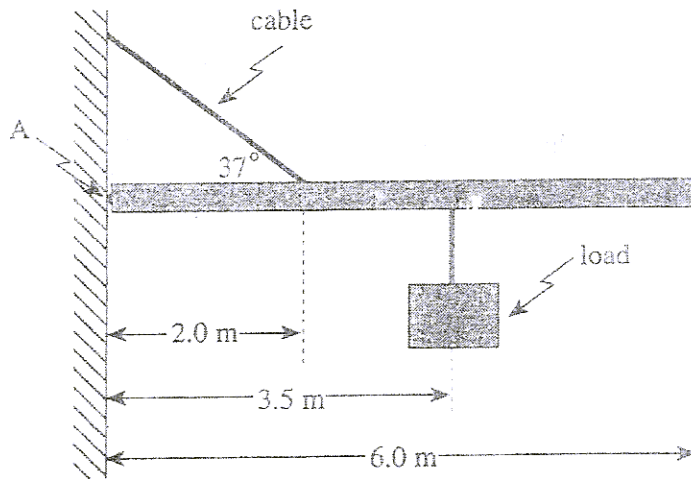
$$\theta = 72.81^\circ$$

$$a = 7.23 \text{ m/s}^2 \text{ [72.81}^\circ \text{ N of E]}$$

3. 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.

6/94

#20

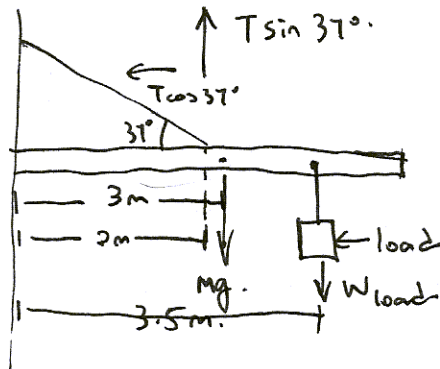


If the maximum tension the cable can withstand is  $2.4 \times 10^3$  N, what is the maximum mass of the load?

$$T = 2400 \text{ N}$$

$$W_{\text{beam}} = mg = 75(9.8) = 735 \text{ N}$$

At the middle of the beam, downward force is 735 N.



$$\sum F_x = 0$$

$$\sum F_y = 0$$

$$\sum \tau = 0$$

$$\sum \tau = 0$$

$$\tau_{(\text{upward tension})} = \tau_{(\text{beam})} + \tau_{(\text{load})}$$

$$(T \sin 37^\circ)(2 \text{ m}) = 735(3 \text{ m}) + W_{\text{load}}(3.5 \text{ m})$$

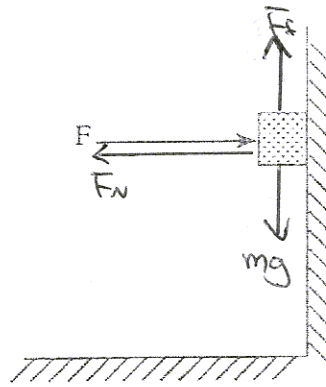
$$2888.71 \text{ N} = 2205 \text{ N} + W_{\text{load}}(3.5 \text{ m})$$

$$W_{\text{load}} = \frac{2888.71 - 2205}{3.5} = 195.35 \text{ N}$$

$$M_{\text{load}} = \frac{195.35}{9.8} = 19.9 \text{ kg}$$

1/95 4. What minimum horizontal force  $F$  will just prevent the 5.0 kg block from sliding if the coefficient of friction between the wall and the block is 0.65?

#21



$$F_f = \mu F_N = mg$$

$$F = F_N = \frac{mg}{\mu}$$

$$F = \frac{(5.0 \text{ kg})(9.8 \text{ m/s}^2)}{0.65}$$

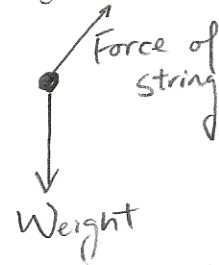
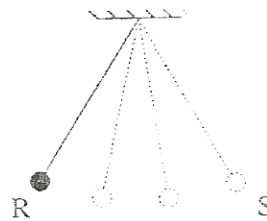
$$= 75 \text{ N}$$

**D**

- A. 6.4 N
- B. 32 N
- C. 49 N
- D. 75 N**

1/95 5. A pendulum is swinging freely between points R and S as shown in the diagram below.

#22

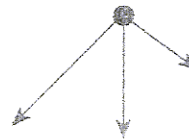


Which of the following diagrams best represents the forces acting on the pendulum bob at point R?

**A.**



B.



C.



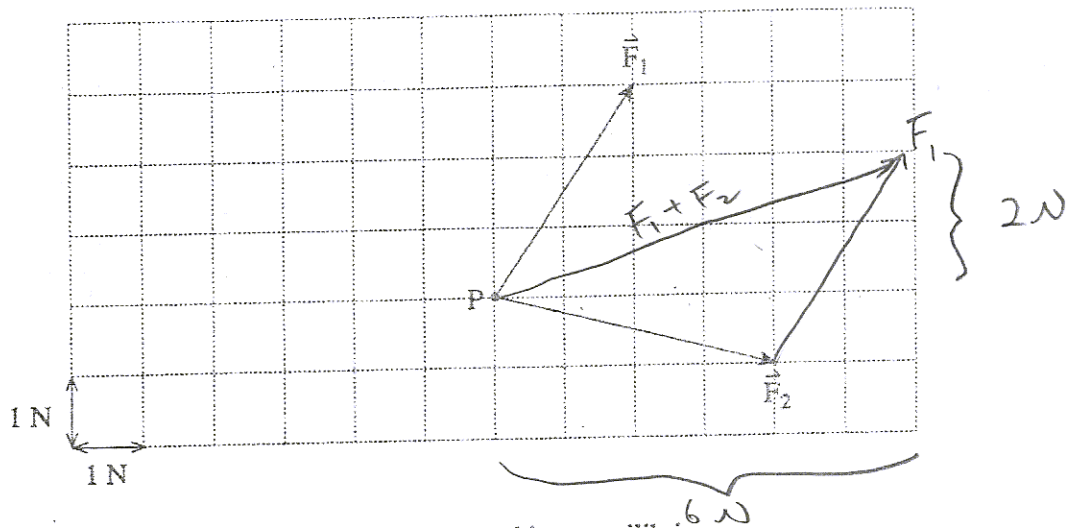
D.



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

1/95

#23



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

$$a^2 + b^2 = c^2$$

$$2^2 + 6^2 = c^2$$

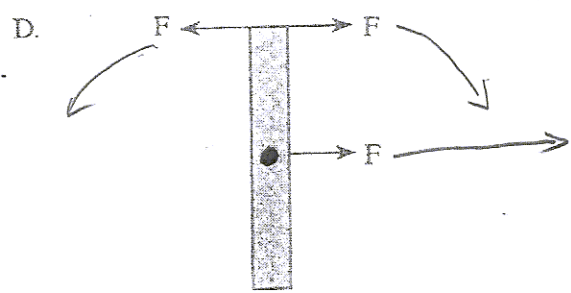
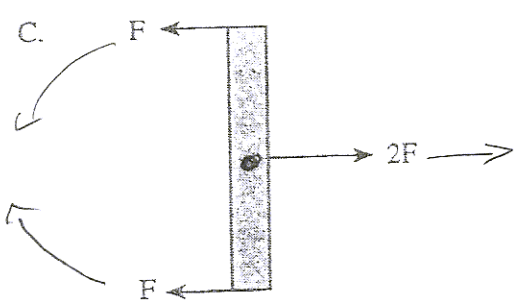
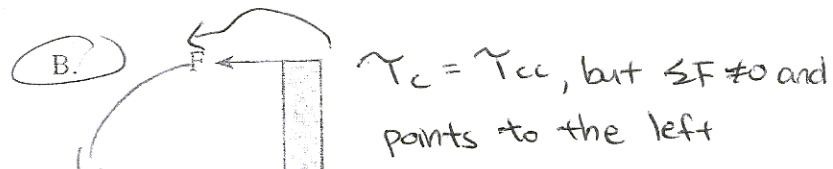
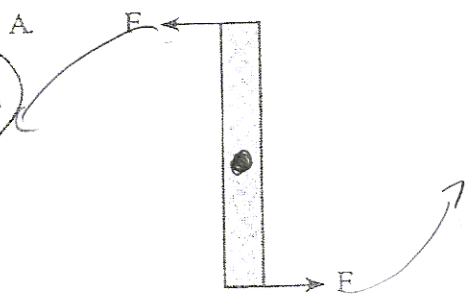
$$40 = c^2$$

$$c = 6.3 \text{ N}$$

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

1/95

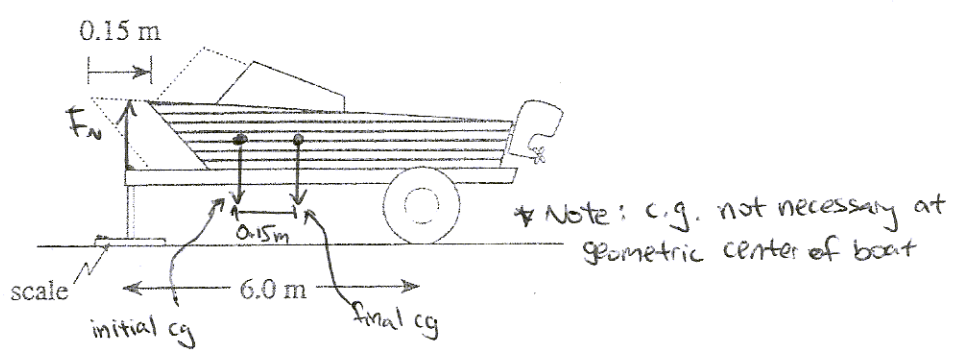
#24



rotation at centre point

11. 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.

#25

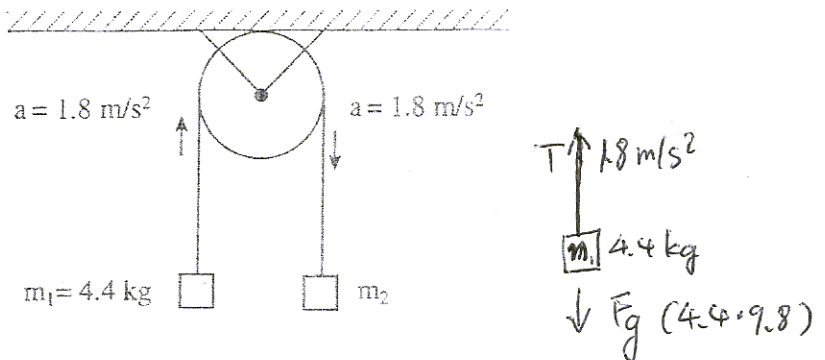


- A. 440 kg
- B. 1 600 kg
- C. 1 700 kg
- D. 3 400 kg

let  $x_{cg}$  represent position of center of gravity, point of rotation is set at wheel.  
 $\tau_c = \tau_{cc}$   
 $F_N d_1 = F_g d_2$   
 initially:  $(48 \text{ kg})(9.8)(6 \text{ m}) = mg d_2$   
 $d_2 = \frac{(48 \text{ kg})(6 \text{ m})(9.8)}{mg}$   
 then:  $(37 \text{ kg})(9.8)(6 \text{ m}) = mg(d_2 - 0.15)$   
 $(9.8)(37 \text{ kg})(6 \text{ m}) = mg \left( \frac{(48)(6)}{mg} - 0.15 \right)$   
 $21756 = 288 - 0.15mg$   
 $m = 440 \text{ kg}$  **A**

1. The diagram shows a 4.4 kg mass connected by a string to an unknown mass over a frictionless pulley. The system accelerates at  $1.8 \text{ m/s}^2$  in the direction shown.

#26

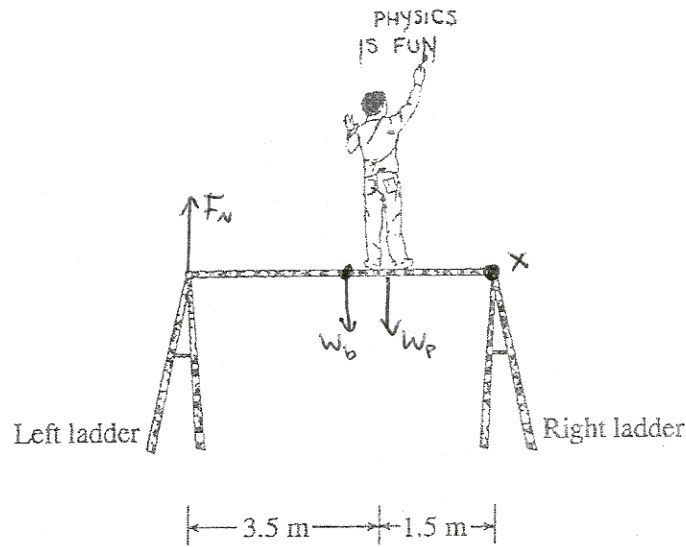


- a) Draw and label a free body diagram for the 4.4 kg mass.
- b) Calculate the tension in the string.
- c) Find mass  $m_2$ .

~~W1 + T = ma~~  
 $W_1 + T = ma$   
 $W_2 - T = ma$   
 $T = ma - W_1 = W_2 - ma$   
 $T = 4.4(1.8) - (4.4)(9.8)$   
 $T = 51 \text{ N}$  (magnitude)  
 $m_2 = 51 / (9.8 - 1.8)$   
 $m_2 = 6.4 \text{ kg}$

- 1/95 3. 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)

\*27



To Find Force exerted by left ladder, set rotational point of board at the far right point X.

$$\sum \tau = 0$$

$$\tau_c = \tau_{cc}$$

$$F_N d_1 = W_b d_2 + W_p d_3$$

$$F_N (5.0 \text{ m}) = (16 \text{ kg})(9.8)(2.5 \text{ m}) + (75 \text{ kg})(9.8)(1.5 \text{ m})$$

$$F_N = \boxed{299 \text{ N}} \leftarrow \text{force exerted by left ladder.}$$

$$\sum F_y = 0$$

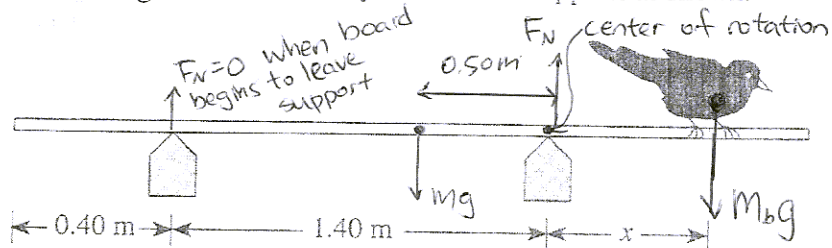
$$W_b + W_p = F_{\text{left}} + F_{\text{right}}$$

$$(16 \text{ kg})(9.8) + (75 \text{ kg})(9.8) = 299 \text{ N} + F_{\text{right}}$$

$$F_{\text{right}} = \boxed{593 \text{ N}}$$

6/95 3. A 0.75 kg board of length 2.60 m initially rests on two supports as shown.

# 28



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)

See bottom of page

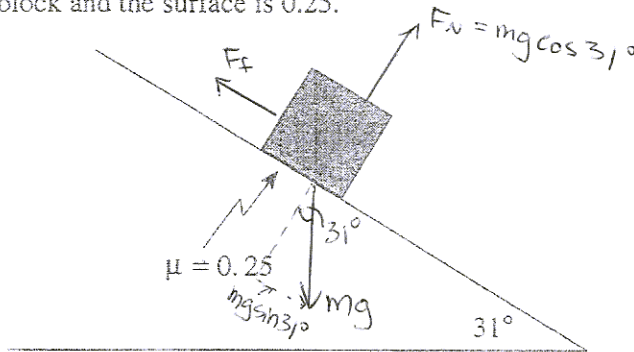
b) What force does the right-hand support exert on the board at that instant? (2 marks)

$$\sum F_y = 0$$

$$F_N = mg + m_{bg} = (0.75 \text{ kg})(9.8 \text{ m/s}^2) + (1.20 \text{ kg})(9.8 \text{ m/s}^2) = \boxed{19 \text{ N}}$$

6/95 1. An 87 kg block slides down a  $31^\circ$  slope as shown in the diagram below. The coefficient of friction between the block and the surface is 0.25.

# 29



What is the acceleration of the block?

(7 marks)

$$\sum F = ma$$

$$F_{gx} - F_f = ma$$

$$mg \sin \theta - \mu mg \cos \theta = ma$$

$$a = \frac{mg \sin \theta - \mu mg \cos \theta}{m} = g \sin \theta - \mu g \cos \theta$$

$$= (9.8 \text{ m/s}^2) \sin 31^\circ - (0.25)(9.8 \text{ m/s}^2) \cos 31^\circ$$

$$= \boxed{2.9 \text{ m/s}^2}$$

28. a)  $\tau_c = \tau_{cc}$

$$F_c x = F_{cc} d$$

$$m_b g x = m g d$$

$$(1.20 \text{ kg})(9.8 \text{ m/s}^2) x = (0.75 \text{ kg})(9.8 \text{ m/s}^2)(0.50 \text{ m})$$

$$x = \boxed{0.31 \text{ m}}$$



6/95

1. An object is sliding down a smooth incline. If friction is negligible, the object has

#30

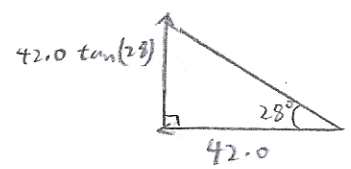
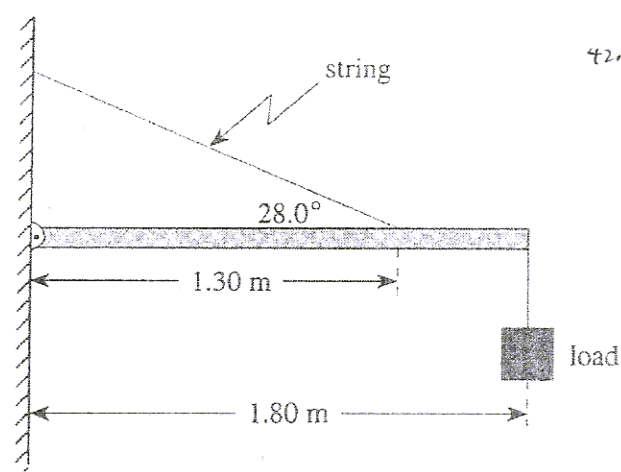
- A. constant velocity.
- B. constant momentum.
- C. constant acceleration.
- D. constant displacement.

$a = \frac{F}{m}$ , since force and mass are both constant, acceleration is constant.

6/95

8. 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.

#31



$$42.0 \tan(28) = 22.33 \text{ N}$$

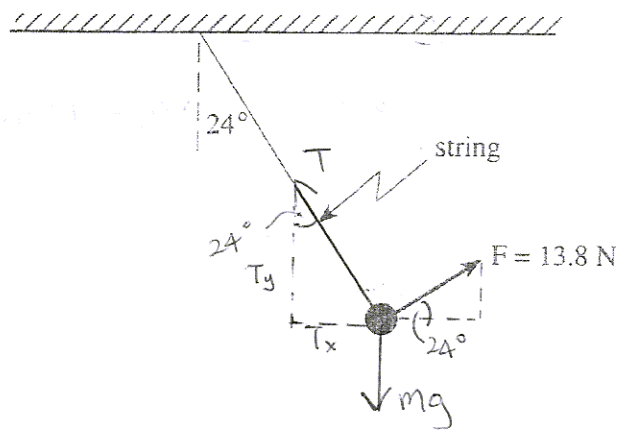
$$22.33 \times 1.3 \div 1.8 = 16.12 \text{ N}$$

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

6/95

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

#32



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

$$\sum F_y = 0$$

$$T_y + F_y - mg = 0$$

$$\frac{F \cos 24^\circ}{\tan 24^\circ} + F \sin 24^\circ - 9.8 m = 0$$

$$m = \boxed{3.5 \text{ kg}}$$

$$T_x = F_x = F \cos 24^\circ$$

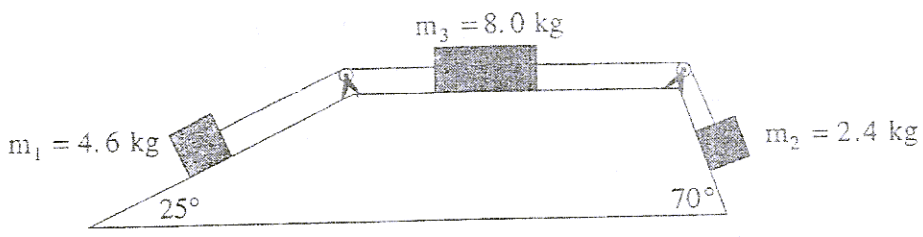
$$\tan 24^\circ = \frac{T_x}{T_y}$$

$$T_y = \frac{F \cos 24^\circ}{\tan 24^\circ}$$

8/95

5. Three masses connected by a light string are arranged on frictionless surfaces, as shown in the diagram below.

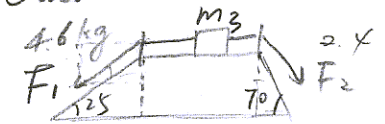
# 33



The strings pass over frictionless pulleys. Determine the direction and magnitude of the acceleration of  $m_1$ .

	DIRECTION OF $m_1$	ACCELERATION ( $m/s^2$ )
A	up incline	0.20
B	down incline	0.20
C	up incline	0.43
D	down incline	0.43

Question 33



$F_{1H} = 4.6 \times \sin 55$   
 $F_{1V} = 4.6 \times \sin 25 \times g \checkmark$   
 $F_{2H} = 2.4 \times \sin 70 \cdot g \checkmark$   
 $F_{2V} = 2.4 \times \sin 20$

4. What is the frictional force due to air resistance on a 0.50 kg object falling vertically with an acceleration of  $8.5 m/s^2$ ?

# 34

- A. 0.65 N
- B. 4.3 N
- C. 4.9 N
- D. 9.2 N

Without air resistance, the downward acceleration should be  $9.8 m/s^2$ .

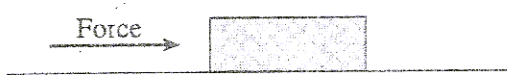
$\therefore \Delta a = -8.5 - (-9.8) = +1.3 m/s^2$   
 $\therefore F = m \cdot \Delta a = 0.50 kg \cdot 1.3 m/s^2 = 0.65 N$

$F_{1V} - F_{2V} = -3.05 N$   
 $\frac{F_{1V} - F_{2V}}{m_{total}} = a_{total} = -0.203 m/s^2$

8/95

1. A constant force is applied to an object on a frictionless surface, as shown in the diagram below.

# 35



The resulting motion has

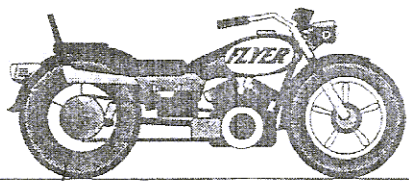
- A. constant velocity.
- B. constant momentum.
- C. constant acceleration.
- D. constant kinetic energy.

Since the surface is frictionless,  $\therefore$  without any forces outside of this object, this object will keep going and never change its own state according to the Newton's First Law of Motion.

Now here is only one force add to the object with a constant quantity.  $\therefore$  the object will have an constant acceleration if no other forces is added to.

8/95 10. The motorcycle shown has a mass of 200 kg and a wheel base of 1.8 m.

#36



the rear wheel  $\leftarrow 1.8 \text{ m} \rightarrow$

If the rear wheel exerts a 1200 N force on the ground, find how far the motorcycle's centre of gravity is located from the front wheel.

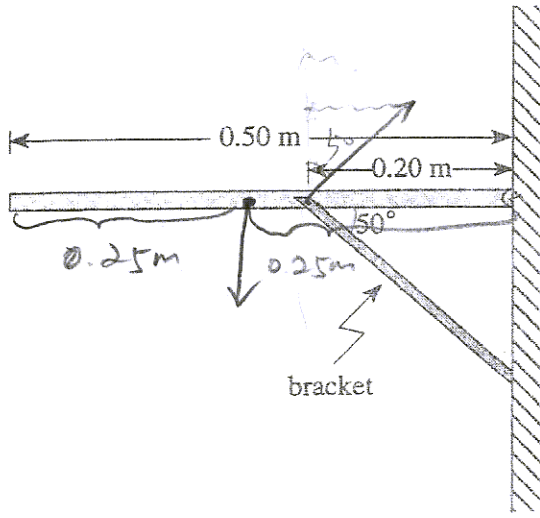
- A. 0.70 m
- B. 0.90 m
- C. 1.1 m
- D. 1.2 m

#36. the total gravity of the motorcycle is  $200 \cdot g = 1960 \text{ N}$ .  
 $\therefore$  the rear exerts part of the gravity. 1200 N, the front one exerts all the rest =  $1960 - 1200 = 760 \text{ N}$

Assume the distance between the rear wheel and the center of gravity of the motorcycle is  $x \text{ m}$   
 $m = (1.8 - x) = \frac{1200 \text{ N}}{760 \text{ N}}$   
 $\Rightarrow x = 1.1 \text{ m}$

8/95 9. A uniform 3.0 kg shelf of width 0.50 m is supported by a bracket, as shown in the diagram below.

#37



#37. the gravity of the shelf is 3.0 kg, which gives the bracket a pressing force as

$$\frac{g \cdot 3.0 \text{ kg} \times 0.5/2}{0.2 \text{ m}} = 3.75 \cdot g = 36.75 \text{ N}$$

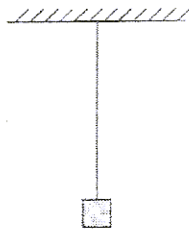
What force does the bracket exert on the shelf?

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

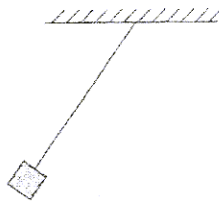
$\therefore$  the total force exerted by the bracket is  $\frac{36.75 \text{ N}}{\sin(90-50)} = 57.17 \text{ N} \approx 57 \text{ N}$

7. A heavy object initially hangs from a piece of thread. When the object is drawn aside and released, the thread is observed to break before the object reaches its lowest point. Using principles of physics, explain why the thread was strong enough to initially suspend the mass but not strong enough to support it when swinging. (4 marks)

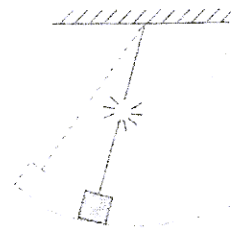
#38



Object suspended in equilibrium



Object released

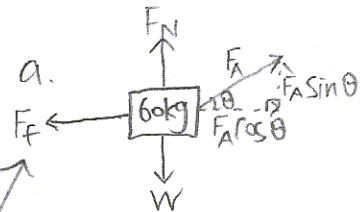
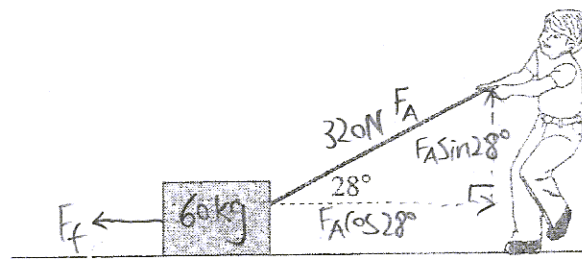


Thread breaks

While object is swinging, the string must provide a tension that is greater than the object's weight in order to maintain the object's circular motion. This extra tension may exceed the string's maximum tension and cause the string to break.

- 8/95 3. 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.

#39



- 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)

$$F_f = F_A \cos 28^\circ$$

$$= 283 \text{ N}$$

- c) Calculate the normal force exerted by the ground on the block. (2 marks)
- $$W - F_A \sin \theta = F_N$$
- $$F_N = 60 \times 9.8 - 320 \sin 28^\circ = 573 \text{ N}$$
- d) Calculate the minimum coefficient of friction between the block and the ground. (1 mark)

$$F_f = \mu F_N$$

$$283 = \mu \cdot 573$$

$$\mu = 0.49$$

- 6/96 5. Force  $F$  gives mass  $m_1$  an acceleration of  $4.0 \text{ m/s}^2$ . The same force  $F$  gives mass  $m_2$  an acceleration of  $2.0 \text{ m/s}^2$ . What acceleration would force  $F$  give to the two masses  $m_1$  and  $m_2$  if they were glued together?

#40

- A.  $1.0 \text{ m/s}^2$   
 B.  $1.3 \text{ m/s}^2$   
 C.  $3.0 \text{ m/s}^2$   
 D.  $6.0 \text{ m/s}^2$

$$a_1 = \frac{F}{m_1} \quad a_2 = \frac{F}{m_2}$$

$$4.0 \text{ m/s}^2 = \frac{F}{m_1} \quad 2.0 \text{ m/s}^2 = \frac{F}{m_2}$$

$$m_1 = \frac{F}{4.0 \text{ m/s}^2} \quad m_2 = \frac{F}{2.0 \text{ m/s}^2}$$

$$m_1 = \frac{1}{2} \cdot \frac{F}{2.0 \text{ m/s}^2}$$

$$m_1 = \frac{1}{2} m_2$$

$$2m_1 = m_2$$

$$a_{\text{total}} = \frac{F}{m_1 + m_2}$$

$$a_{\text{total}} = \frac{F}{m_1 + 2m_1}$$

$$= \frac{F}{3m_1}$$

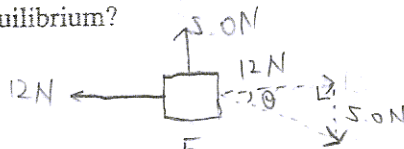
$$= \frac{1}{3} \frac{F}{m_1}$$

$$= \frac{1}{3} \times 4.0 \text{ m/s}^2 = 1.3 \text{ m/s}^2$$

- 8/96 10. Two forces,  $12 \text{ N}$  west and  $5.0 \text{ N}$  north, act on an object. What is the direction of a third force that would produce static equilibrium?

#41

- A.  $23^\circ$  south of east  
 B.  $23^\circ$  north of west  
 C.  $67^\circ$  south of east  
 D.  $67^\circ$  north of west



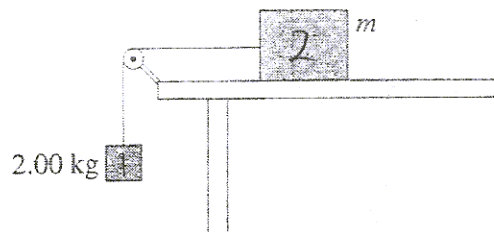
$$\tan \theta = \frac{5}{12}$$

$$\theta = \tan^{-1}\left(\frac{5}{12}\right)$$

$$\theta = 23^\circ \text{ South of East.}$$

- 5/96 4. The frictionless system shown below accelerates at  $1.60 \text{ m/s}^2$  when released.

#42



Find the tension in the string while the system is accelerating.

- A.  $3.20 \text{ N}$   
 B.  $16.4 \text{ N}$   
 C.  $19.6 \text{ N}$   
 D.  $22.8 \text{ N}$

$$F = ma$$

$$mg - T = ma$$

$$T = mg - ma$$

$$T = m(9.8 - 1.60)$$

$$T = 8.2m_1$$

$$T = 8.2 \times 2.00$$

$$T = 16.4 \text{ N}$$

- 6/96 3. 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.

43

b)  $\tau_c = \tau_{cc}$

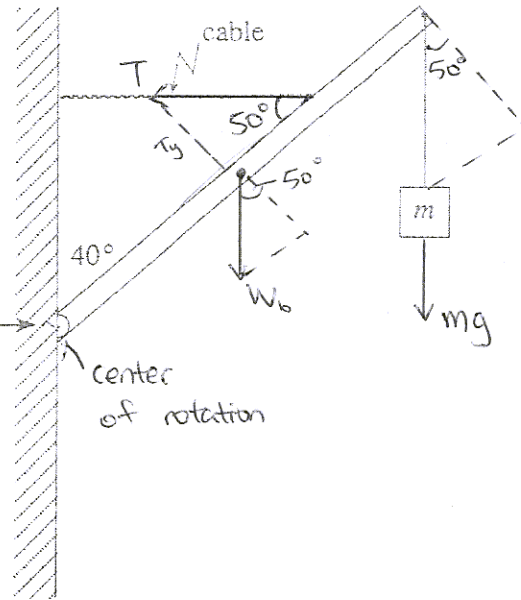
$W_{og}d_1 + mgd_2 = T_y d_3$

$m_{og}d_1 + mgd_2 = T \sin 50^\circ d_3$

$mg \cos 50^\circ d_1 + mg \cos 50^\circ d_2 = T \sin 50^\circ d_3$

$(350 \text{ kg})(9.8 \cos 50^\circ)(2.1 \text{ m}) + m(9.8)(\cos 50^\circ)(4.2 \text{ m}) =$   
 $(1.3 \times 10^4 \text{ N}) \sin 50^\circ (3.0 \text{ m})$

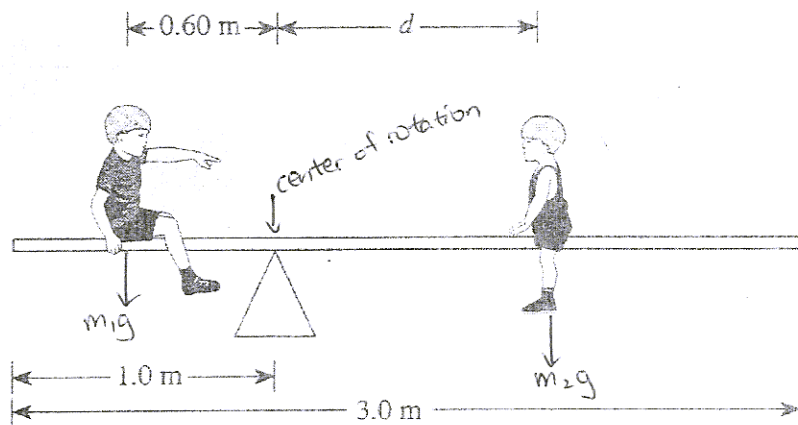
$m = 954 \text{ kg}$



- 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  $1.3 \times 10^4 \text{ N}$ , what maximum mass,  $m$ , can be suspended from the end of the beam? (5 marks)

- 6/96 11. A 3.0 m uniform beam of mass 15 kg is pivoted 1.0 m from the end as shown below.

44



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

$\tau_c = \tau_{cc}$

$m_2 g d = m_1 g (0.60 \text{ m})$

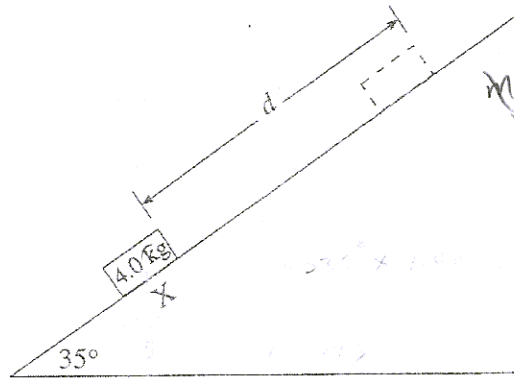
$(20 \text{ kg}) d = (35 \text{ kg})(0.60 \text{ m})$

$d = 1.1 \text{ m}$

C

8/96 4. A 4.0 kg block has a speed of 9.0 m/s at X

#45



$$\begin{aligned} F &= ma \\ mg \sin \theta &= ma \\ a &= 9.8 \sin 35^\circ \\ &= 5.621 \\ v_f^2 &= v_i^2 + 2ad \\ d &= \frac{v_f^2}{2a} \\ &= \frac{9^2}{2 \times 5.621} \\ &= 7.2 \text{ m} \end{aligned}$$

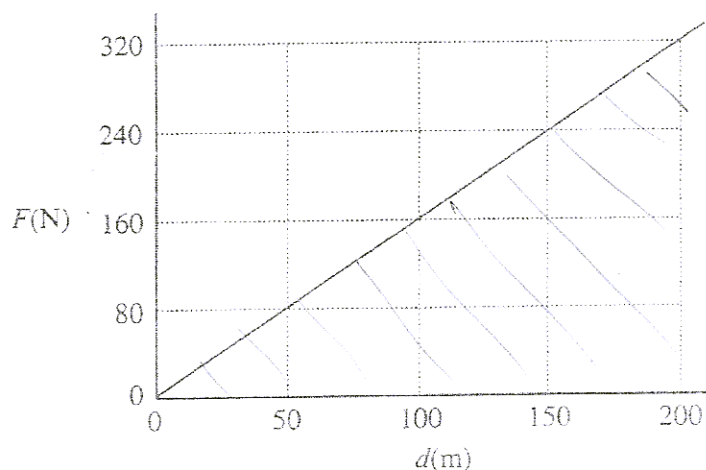
What is the maximum distance,  $d$ , travelled by the block? Ignore friction.

- A. 0.92 m
- B. 1.6 m
- C. 4.1 m
- D. 7.2 m

$$\begin{aligned} F &= ma \\ mg \sin \theta &= ma \\ a &= \sin 35^\circ \times 9.8 \text{ m/s}^2 \\ &= 5.621 \text{ m/s}^2 \\ v_f^2 &= v_i^2 + 2ad \\ d &= \frac{v_f^2}{2a} \\ d &= \frac{9^2}{2 \times 5.621} \\ &= 7.2 \text{ m} \end{aligned}$$

- 8/96 2. A 24 kg rocket car is initially at rest on a frictionless horizontal surface. The engine is ignited and the graph below shows thrust force,  $F$ , versus distance travelled,  $d$ , for the rocket car. Find the rocket car's speed after it has travelled 200 m. (7 marks)

#46



$$W = \text{Area} = \Delta KE$$

$$\frac{1}{2}(200)(320) = \frac{1}{2} m v^2$$

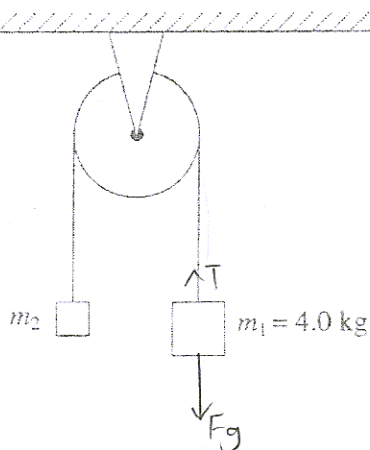
$$(200)(320) = 24 \text{ kg } v^2$$

$$v = \sqrt{\frac{(200)(320)}{24}}$$

$$= \boxed{52 \text{ m/s}}$$

- 8/96 5. The tension in the string shown is 12 N. Find the acceleration of mass  $m_1$ .

#47



- A.  $3.0 \text{ m/s}^2$
- B.  $6.4 \text{ m/s}^2$
- C.  $6.8 \text{ m/s}^2$
- D.  $13 \text{ m/s}^2$

$$a = \frac{\sum F}{m}$$

$$= \frac{m_1 g - T}{m_1}$$

$$= \frac{(4.0 \text{ kg})(9.8 \text{ m/s}^2) - 12 \text{ N}}{4.0 \text{ kg}}$$

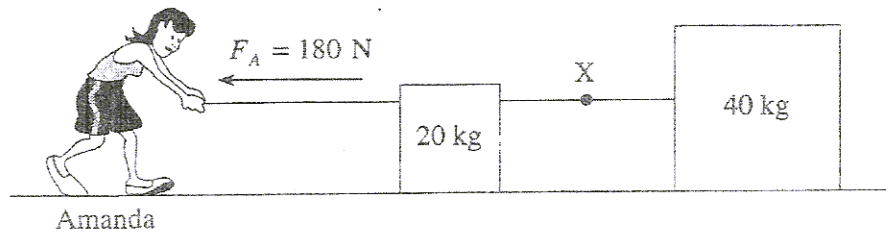
$$= 6.8 \text{ m/s}^2 \quad \boxed{C}$$



8/96

1. a) Amanda exerts a horizontal force of 180 N on a piece of rope causing two blocks of mass 20 kg and 40 kg to accelerate. Friction on the blocks is negligible. Find the tension force at X in the rope joining the two blocks together. (5 marks)

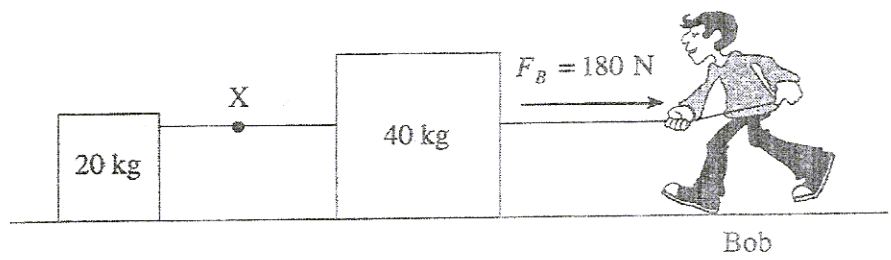
≠ 148



$$180 \div (20+40) = 3 \text{ m/s}^2$$

$$T = 40 \times 3 = 180 - (20 \times 3) = 120 \text{ N}$$

- b) Bob exerts a force of equal magnitude in the opposite direction on an identical pair of blocks.



How does the tension force at X compare to the value in part a)? (Circle one.) (1 mark)

- i) The tension force is the same.
- ii) The tension force is greater than in a).
- iii) The tension force is smaller than in a).

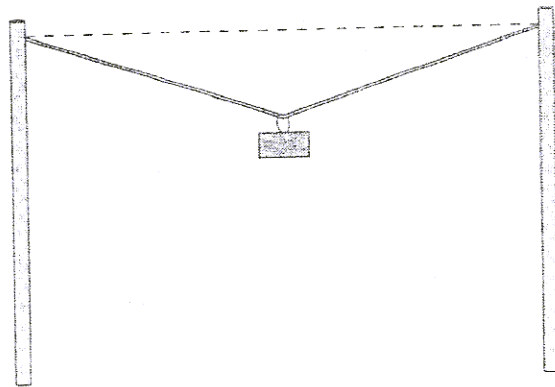
- c) Using principles of physics, explain your answer to part b). (3 marks)

In both situations, the acceleration is equal. However, in Bob's situation, the tension at X accelerates a smaller mass. According to  $F=ma$ , a smaller mass requires a smaller tension to be accelerated at the same rate.

7. A wire is stretched between two posts. A mass is suspended near the centre as shown below.

9/96

#49



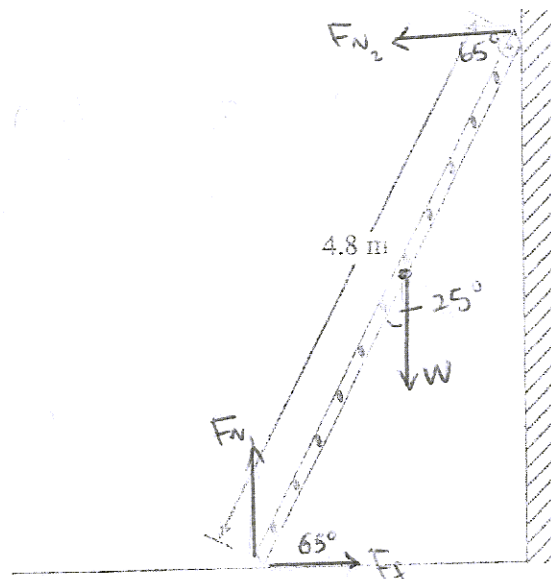
If the tension in the wire were increased, is it possible to make the wire perfectly horizontal?  
Explain your answer in terms of forces. (4 marks)

No. The tension force must have a vertical component to balance the weight of the mass. Since tension acts along the string, the vertical component of tension causes the string to bend.

8/96

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

#50



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)

$$F_f = F_{N_2}$$

$$\sum \tau = 0$$

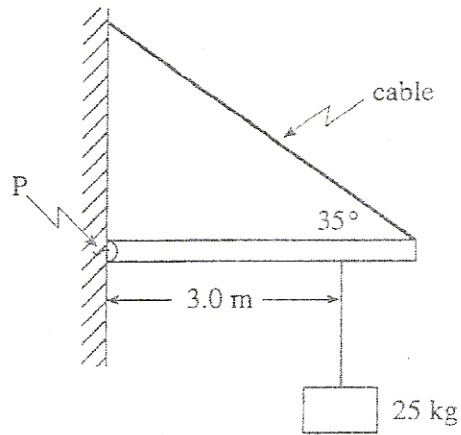
$$W \sin 25^\circ d_1 = F_{N_2} \sin 65^\circ d_2$$

$$(16 \text{ kg})(9.8 \text{ m/s}^2) \sin 25^\circ (2.4 \text{ m}) = F_{N_2} \sin 65^\circ (4.8 \text{ m})$$

$$F_{N_2} = F_f = \boxed{37 \text{ N}}$$

- 1/97 3. 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.

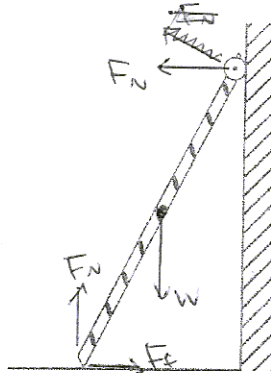
#51



- 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)

- 1/97 9. A uniform ladder leans against a frictionless wall as shown.

#52



Which of the following diagrams best shows the forces acting on the ladder?

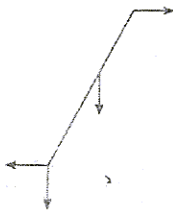
A.



B.



C.

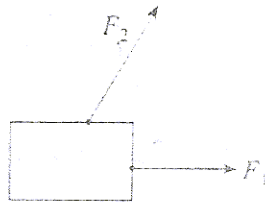


D.



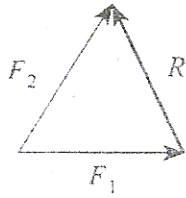
1/97 2. Two forces act on an object as shown in the diagram.

53

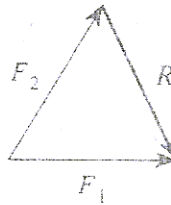


Which of the following best shows the resultant  $R$  of these forces?

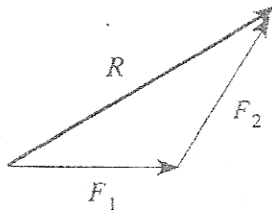
A.



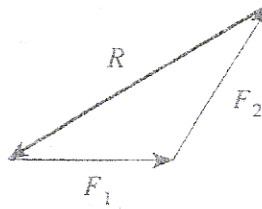
B.



C.



D.



Join the vectors, tail to head

1/97 5. A 45 kg toboggan and rider decelerate on level snow at  $0.53 \text{ m/s}^2$ . What is the coefficient of friction between the toboggan and the snow?

- #54  
 A. 0.012  
 B. 0.054  
 C. 0.22  
 D. 0.53

$$F_{fr} = \mu F_N \quad F_N = mg \Rightarrow (45 \text{ kg})(-9.80) = -441$$

$$F_{fr} = F_{Net} = ma \Rightarrow (45 \text{ kg})(-0.53) = -23.9 \quad \mu = \frac{F_{fr}}{F_N} = \frac{-23.9}{-441} = 0.054$$

1/97 4. A 75 kg man stands on a scale while accelerating upwards in an elevator. If the scale reads 850 N, what is the magnitude of the acceleration of the elevator?

- #55  
 A.  $1.2 \text{ m/s}^2$   
 B.  $1.5 \text{ m/s}^2$   
 C.  $9.8 \text{ m/s}^2$   
 D.  $11 \text{ m/s}^2$

$$W = (75 \text{ kg})(9.80) = 735 \text{ N} \quad F_{NET} = 850 - 735 = 115 \text{ N}$$

$$F_{NET} = ma \Rightarrow a = \frac{115 \text{ N}}{75 \text{ kg}} = 1.5 \text{ m/s}^2$$

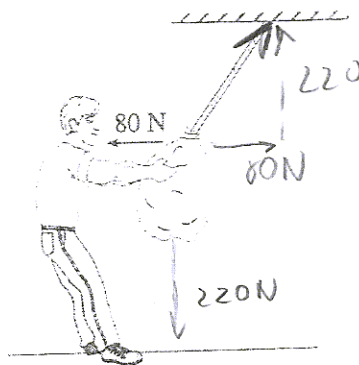
1/97 7. The 2.0 kg head of an axe strikes a tree horizontally at 40 m/s. The blade penetrates 0.040 m into the tree. What is the average force exerted by the blade on this tree?

- #56  
 A.  $2.0 \times 10^1 \text{ N}$   
 B.  $2.0 \times 10^3 \text{ N}$   
 C.  $2.0 \times 10^4 \text{ N}$   
 D.  $4.0 \times 10^4 \text{ N}$

$$\vec{a} = \frac{v_f^2 - v_i^2}{2d} \Rightarrow \vec{a} = \frac{-(40)^2}{2(0.04)} = 2.0 \times 10^4 \text{ m/s}^2$$

$$F_{NET} = m\vec{a} \Rightarrow (2.0 \text{ kg})(2.0 \times 10^4 \text{ m/s}^2) = 4.0 \times 10^4 \text{ N}$$

1/97 10. 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?

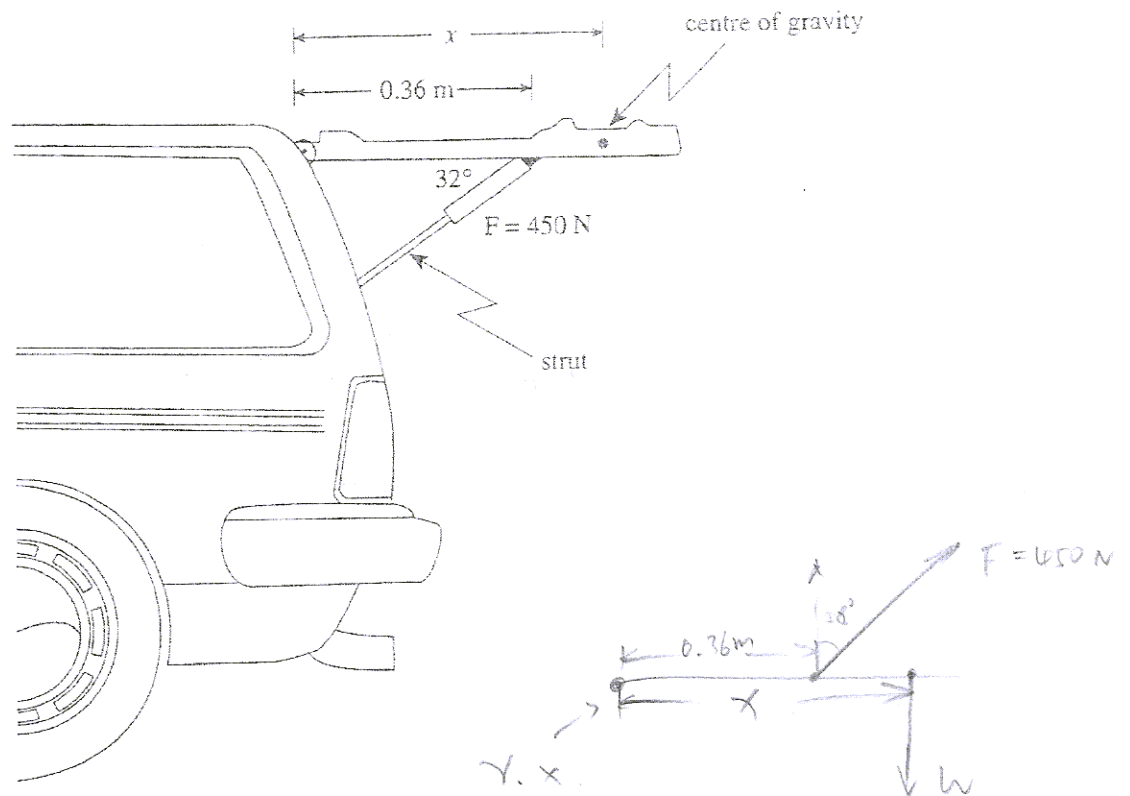
- #57  
 A.  $1.4 \times 10^2 \text{ N}$   
 B.  $2.2 \times 10^2 \text{ N}$   
 C.  $2.3 \times 10^2 \text{ N}$   
 D.  $3.0 \times 10^2 \text{ N}$

$$F_T = \sqrt{220^2 + 80^2}$$

$$F_T = 234 \text{ N}$$

- 6/97 3. The diagram shows the rear door of a station wagon supported horizontally by a strut. The mass of the door is 18 kg and the compression force in the strut is 450 N.

#58



- a) Draw and label a free body diagram showing the forces acting on the door. (2 marks)
- b) At what distance,  $x$ , from the hinge is the centre of gravity of the door located? (5 marks)

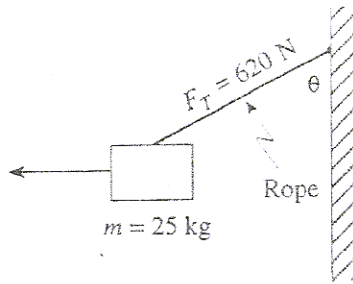
$$\tau_{cw} = \tau_{cw}$$

$$18(9.80)x = (\cos 32^\circ)(450)(0.36)$$

$$x = 0.49 \text{ m}$$

- 6/97 9. A 25 kg block is pulled by a horizontal force. The supporting rope can withstand a maximum tension force of 620 N.

#59



To what maximum angle,  $\theta$ , can the block be pulled without the rope breaking?

- A.  $22^\circ$   
 B.  $23^\circ$   
 C.  $67^\circ$   
 D.  $88^\circ$

$$W = mg = (25 \text{ kg})(9.8 \text{ m/s}^2) = 245 \text{ N}$$

$$\cos \theta F_T \leq 245 \text{ N}$$

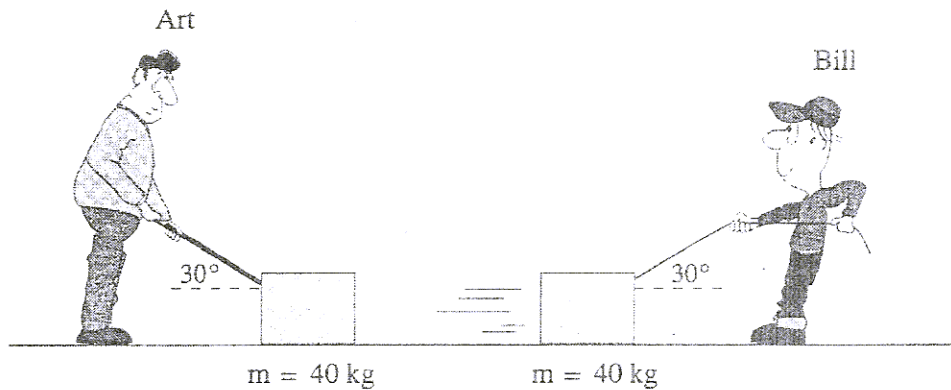
$$\cos \theta = (245 \text{ N} / 620 \text{ N})$$

$$\theta = \cos^{-1}(245 \text{ N} / 620 \text{ N})$$

$$= 67^\circ$$

- 6/97 7. Art and Bill both attempt to move identical 40 kg crates across identical rough surfaces. Art exerts an 80 N force by pushing with a stick. Bill exerts an 80 N force by pulling on a cord. Bill's crate slides across the ground, but Art's will not move.

#60



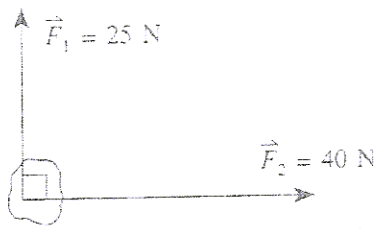
Explain this observation, using principles of physics.

(4 marks)

Since  $F_f = \mu F_n$ , when Art pushes the box, it creates more normal force therefore  $F_f$  is greater, since  $F_f$  is opposite in direction of  $F_A$ , it is harder for Art to move the box.

6/97 8. Two forces act on an object as shown. Find the magnitude of the third force required to achieve translational equilibrium.

#61



- A. 15 N
- B. 33 N
- C. 47 N
- D. 65 N

Third force must have magnitude that is equal to the resultant force.

$$F_r = \sqrt{F_1^2 + F_2^2}$$

$$= \sqrt{25^2 + 40^2} = \boxed{47 \text{ N}}$$

6/97 2. When a 2.0 kg rock is dropped from a cliff it hits the beach at 24 m/s. At what speed would a 4.0 kg rock, dropped from the same cliff, hit the beach? Ignore friction.

#62

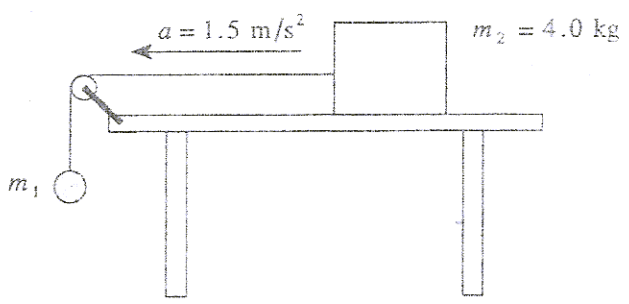
- A. 12 m/s
- B. 24 m/s
- C. 34 m/s
- D. 48 m/s

The acceleration due to gravity is the same for all objects regardless of their masses. Therefore, all objects dropped from the same height will attain the same final velocity.

Answer: 24 m B

6/97 3. The 4.0 kg block shown accelerates across a frictionless horizontal table at 1.5 m/s<sup>2</sup>.

#63



Find the mass of object  $m_1$ .

- A. 0.61 kg
- B. 0.72 kg
- C. 6.0 kg
- D. 26 kg

$$T = m_2 a$$

$$T = W - m_1 a$$

$$m_2 a = F_g - m_1 a$$

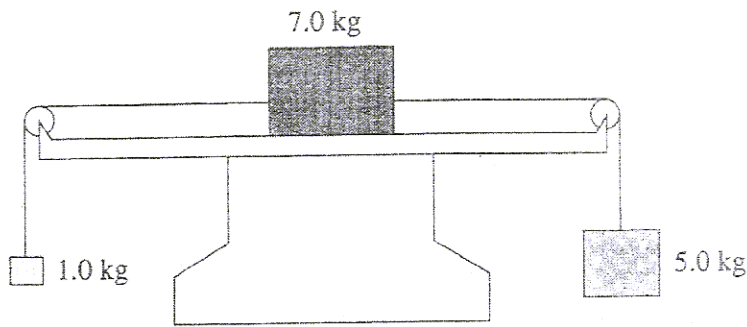
$$m_2 a = m_1 (9.8 - a)$$

$$m = 0.72 \text{ kg}$$



- 8/97 4. Three blocks have masses 1.0 kg, 7.0 kg and 5.0 kg as shown. The horizontal surface is frictionless.

#64



$$\begin{aligned} & (5 \times 9.8 - 1 \times 9.8) \\ & = 39.2 \text{ N} \\ & 39.2 \div (7 + 5 + 1) \\ & = 3.0 \text{ m/s}^2 \end{aligned}$$

What is the magnitude of the acceleration of the system?

- A. 3.0 m/s<sup>2</sup>
- B. 3.8 m/s<sup>2</sup>
- C. 6.5 m/s<sup>2</sup>
- D. 7.8 m/s<sup>2</sup>

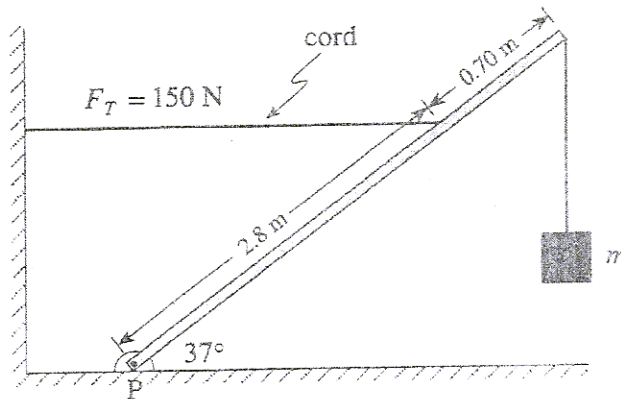
- 8/97 2. Which of the following is not a statement of one of Newton's laws of motion?

#65

- A. For every action force, there is an equal and opposite reaction force. (3rd Law)
- B. If no net force acts on an object, the object will remain at rest, or continue to move at a constant velocity. (1st law)
- C. The acceleration of freely falling objects is proportional to their mass.
- D. If a net force does act on an object, the object will accelerate in the direction of the net force. (implied by 1st and 2nd Law)

- 8/97 9. A uniform 3.5 m beam of negligible mass, hinged at P, supports a hanging block as shown.

#66

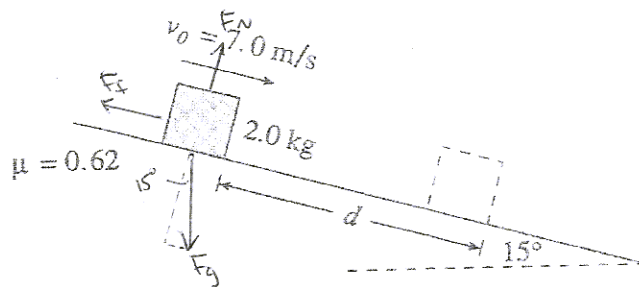


If the tension  $F_T$  in the horizontal cord is 150 N, what is the mass of the hanging block?

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

- 8/97 5. A 2.0 kg block is sliding down a  $15^\circ$  incline. The coefficient of friction is 0.62. At some position the block has a speed of 7.0 m/s.

#67



What distance  $d$  will this block move before coming to rest?

- A. 2.5 m
- B. 4.0 m
- C. 4.2 m
- D. 7.4 m

$$a = \frac{\sum F}{m} = \frac{F_{gx} - F_f}{m} = \frac{mg \sin 15^\circ - \mu mg \cos 15^\circ}{m}$$

$$= \frac{(9.8) \sin 15^\circ - (0.62)(9.8) \cos 15^\circ}{1}$$

$$= -3.33 \text{ m/s}^2$$

$$v_i = 7.0 \text{ m/s} \quad v_f = 0 \text{ m/s} \quad a = -3.33 \text{ m/s}^2 \quad d = ?$$

$$v_f^2 = v_i^2 + 2ad$$

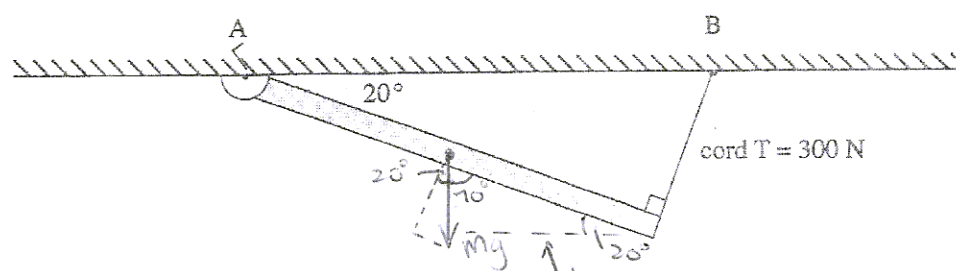
$$0 = 7^2 + 2(-3.33)d$$

$$d = \boxed{7.4 \text{ m}}$$

8/97

3. 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.

#68



this is not a component! It's drawn to show how to determine the angles. (7 marks)

Determine the mass of the beam.

$$\sum \tau = 0$$

$$mgd_1 \cos 20^\circ = Td_2$$

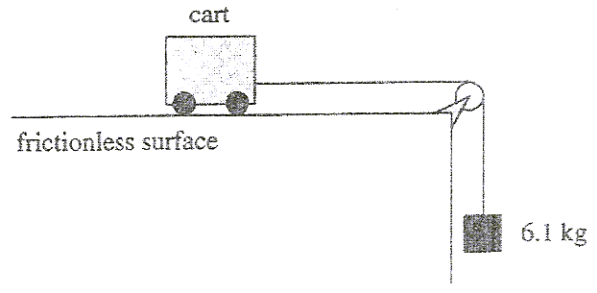
$$m(9.8 \text{ m/s}^2)(1.9 \text{ m}) \cos 20^\circ = (300 \text{ N})(3.8 \text{ m})$$

$$m = 65 \text{ kg}$$

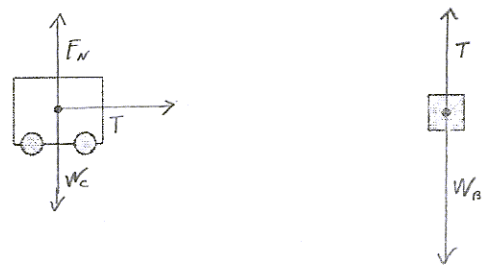
8/97

1. In the diagram shown, the tension in the cord connecting the hanging mass and cart is 43 N.

#69



a) Draw and label a free body diagram for the cart and the hanging mass. (2 marks)



b) Determine the mass of the cart. (5 marks)

$$\sum F_x = T = m_{\text{cart}}(-a) \rightarrow 43 \text{ N} = -a m_{\text{cart}}$$

$$\sum F_y = W_B - T = m_{\text{block}} a \rightarrow 59.78 \text{ N} - 43 \text{ N} = (6.1 \text{ kg})(a)$$

$$a = 2.75 \text{ m/s}^2$$

$$m = \sum F / a = 43 \text{ N} / 2.75 \text{ m/s}^2 = 15.6 \text{ kg}$$

## Dynamics & Equilibrium

1	<u>48° Increases</u>	31	<u>A</u>	61	<u>C</u>
2	<u>4.4 m/s<sup>2</sup> 65 N</u>	32	<u>d</u>	62	<u>B</u>
3	<u>B</u>	33	<u>A</u>	63	<u>B</u>
4	<u>C</u>	34	<u>A</u>	64	<u>A</u>
5	<u>C</u>	35	<u>C</u>	65	<u>C</u>
6	<u>d</u>	36	<u>C</u>	66	<u>A</u>
7	<u>B</u>	37	<u>C</u>	67	<u>d</u>
8	<u>B</u>	38	<u>See text</u>	68	<u>65 Kg</u>
9	<u>d</u>	39	<u>283 N 438 N 0.65</u>	69	<u>15.6 Kg</u>
10	<u>381 N</u>	40	<u>B</u>		
11	<u>A</u>	41	<u>A</u>		
12	<u>B</u>	42	<u>B</u>		
13	<u>d</u>	43	<u>954 Kg</u>		
14	<u>A</u>	44	<u>d A</u>		
15	<u>A</u>	45	<u>d</u>		
16	<u>C</u>	46	<u>52 m/s</u>		
17	<u>B</u>	47	<u>C</u>		
18	<u>d</u>	48	<u>120 N (iii)</u>		
19	<u>7.2 m/s<sup>2</sup></u>	49	<u>No</u>		
20	<u>19.9 Kg</u>	50	<u>37 N 0.23</u>		
21	<u>d</u>	51	<u>449 N 367 N</u>		
22	<u>A</u>	52	<u>A</u>		
23	<u>C</u>	53	<u>C</u>		
24	<u>B</u>	54	<u>B</u>		
25	<u>A</u>	55	<u>B</u>		
26	<u>51 N 64 Kg</u>	56	<u>d</u>		
27	<u>593 N 299 N</u>	57	<u>C</u>		
28	<u>31 cm 19 N</u>	58	<u>0.49 m</u>		
29	<u>2.9 m/s<sup>2</sup></u>	59	<u>C</u>		
30	<u>C</u>	60	<u>Greater Friction</u>		