2.3 Interactions, Partial FBDs

Preparatory Problems

2.3.1 How does one know what forces and moments to use in

a) the statics force balance and moment-balance equations? *

b) the dynamics linear momentum balance and angular momentum balance equations? *

2.3.2 In a free-body diagram of a whole man standing with his right hand extended how do you show the force of his right arm on his body? *

2.3.3 Reproduce the first column of the table in fig. 2.42 on page 169 for the force acting on your right foot from the ground as you step on a stair.

2.3.4 Reproduce the second column of the table in fig. 2.42 on page 169 for a force in the direction of $3\hat{\imath} + 4\hat{\jmath}$ but with unknown magnitude.

2.3.5 Reproduce the third column of the table in fig. 2.42 on page 169 for a 50 N force in the direction of the vector $3\hat{\imath}+4\hat{\jmath}$.

More-Involved Problems

2.3.6 Simple massless pulleys. Draw free-body diagrams of

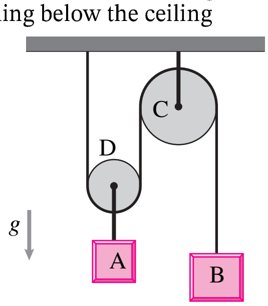
a) mass A with a little bit of rope,

b) mass B with a little bit of rope,

c) Pulley C with three bits of rope,

d) Pulley D with three bits of rope, and

e) The system consisting of everything below the ceiling



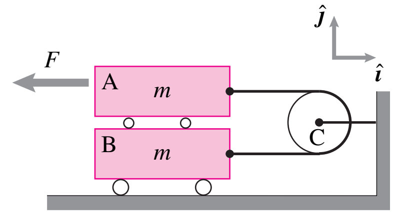
Problem 2.3.6

2.3.7 For the block and pulley arrangement shown in the figure, assume negligible friction at the wheels. Draw the free-body diagrams of

a) the upper mass A,

b) the lower mass B, and

c) the pulley C.

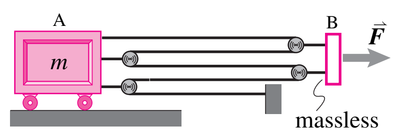


Problem 2.3.7

2.3.8 Multiple pulleys. A goods container of mass m is pulled to the right using a force $\vec{F}$ and the pulley arrangement shown in the figure. Draw the free-body diagram of

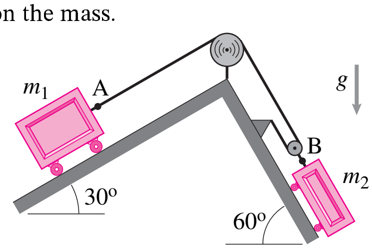
a) the massless block B, and

b) the container A along with the two pulleys attached to it.



Problem 2.3.8

2.3.9
Pulleys on inclined planes. Draw the free-body diagram of mass m_2 and write the expression for each force vector acting on the mass.



Problem 2.3.9

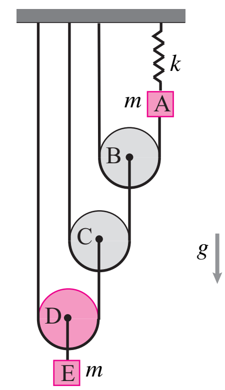
2.3.10 Nested pulleys. In the nested arrangement of pulleys shown in the figure, assume that all the pulleys are massless. Draw the free-body diagram of

a) mass A,

b) mass E, and

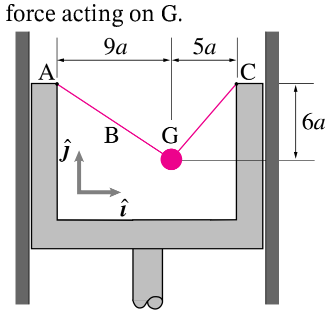
c) pulley D.

Write the expression for the net force on pulley D.



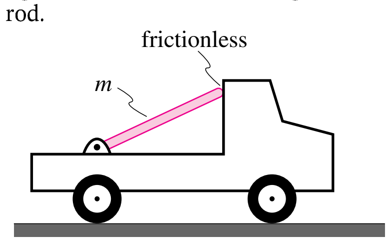
Problem 2.3.10

2.3.11 A point mass m at G is attached to a piston by two inextensible cables. There is gravity. Draw a free-body diagram of the mass with a little bit of the cables and write the vector expression for the net force acting on G.



Problem 2.3.11

2.3.12 A uniform rod of mass m rests in the back of a flatbed truck as shown in the figure. Draw a free-body diagram of the rod.



Problem 2.3.12

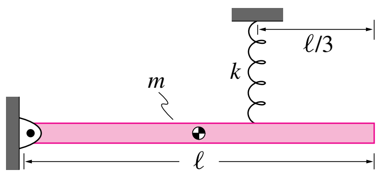
2.3.13 A spring mounted pinned rod. The uniform rigid rod shown in the figure hangs in the vertical plane with the support of the spring shown. In this position the spring is stretched by Δs from its rest length.

a) Draw a free body diagram of the spring.

b) Draw a free-body diagram of the rod.

c) Write an expression for the net force on the rod.

d) Write the expression for the net moment on the rod about its center of mass.

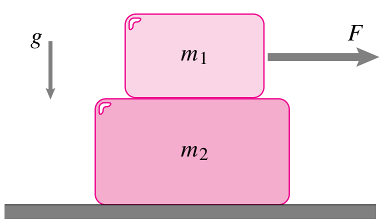


Problem 2.3.13

2.3.14 Two stacked blocks sliding without friction. Two frictionless blocks sit stacked on a frictionless surface. A force F is applied to the top block.

a) Draw free-body diagrams of each block separately.

b) Draw a free-body diagram of the two blocks together.



Problem 2.3.14

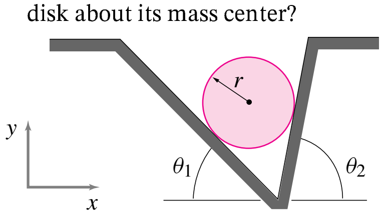
2.3.15 A disk in a frictionless groove. A disc of mass m sits in a wedge shaped groove. There is gravity but no friction.

a) Draw a free-body diagram of the disk.

b) Write vector expressions for the reaction forces from the two walls.

c) Write the expression for the net force on the disk.

d) What is the net moment on the disk about its mass center?



Problem 2.3.15

2.3.16 FBD of an arm throwing a ball. An arm throws a ball up. A crude model of an arm is that it is made of four rigid bodies (shoulder, upper arm, fore-arm and a hand) that are connected with hinges. At each hinge there are muscles that apply torques between the links. Draw a FBD of

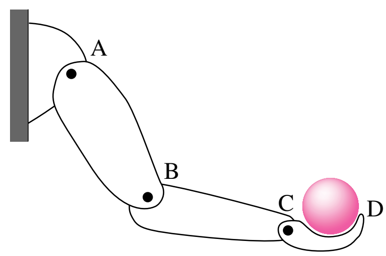
a) the system consisting of the whole arm (three parts, but not the shoulder) and the ball.

b) the ball,

c) the hand, and

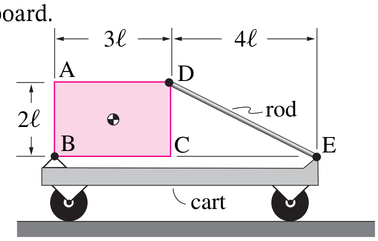
d) the fore-arm,

e) the upper arm,



Problem 2.3.16

2.3.17 A uniform rectangular board of mass m sits on a cart supported by a rod on one corner and a pin at the diagonally opposite corner as shown in the figure. Draw a free-body diagram of the board and write an appropriate vector expression for the force exerted by the rod on the board.



Problem 2.3.17

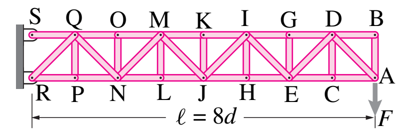
2.3.18 Cantilevered truss A cantilever truss, shown in the figure, is made up of identical horizontal and vertical bars of length d. A vertical force F is applied at point A. The truss is pinned to the wall at joints S and R.

a) Draw a free-body diagram of the entire truss.

b) Cut the truss to the right of bar GE by cutting rods GD, EC and ED, and draw a free-body diagram of that portion of the truss to the right of bar GE.

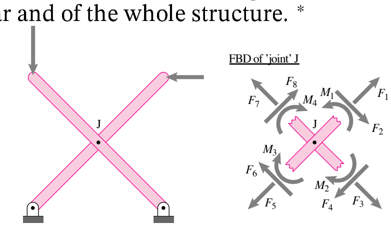
c) Draw a free-body diagram of bar IE.

d) Draw a free-body diagram of the joint at I with a small length of the bars protruding from I.



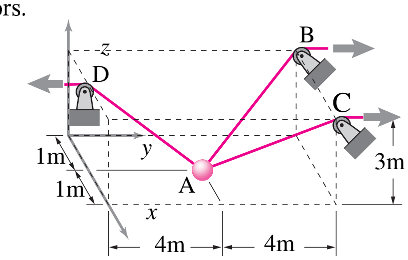
Problem 2.3.18

2.3.19 An X structure. Two rods are pinned together in the middle to form a structure in the shape of 'X' as shown in the figure. A freebody diagram of the joint J with a little bit of the bars near J is shown. Draw free-body diagrams of each bar and of the whole structure. *



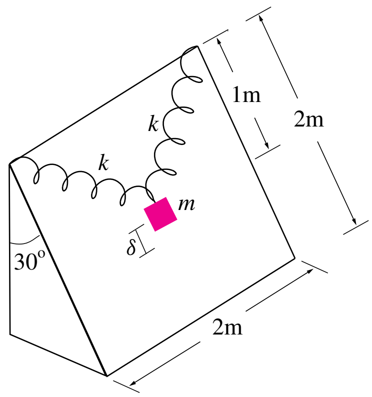
Problem 2.3.19

2.3.20 The strings connected to winches at B, C, and D hold up the mass $m = 3$ kg at A. The relevant dimensions are shown in the figure. There is gravity. Draw a free-body diagram of the mass and express the string forces as appropriate vectors.



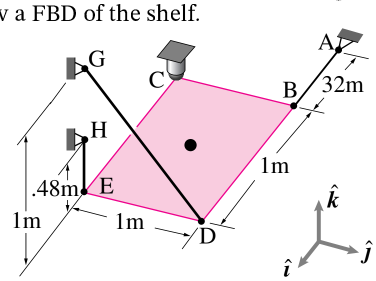
Problem 2.3.20

2.3.21 Mass on inclined plane. A block of mass m rests on a frictionless inclined plane. It is supported by two stretched springs. The mass is pulled down the plane by an amount δ and released. Draw a FBD of the mass just after it is released.



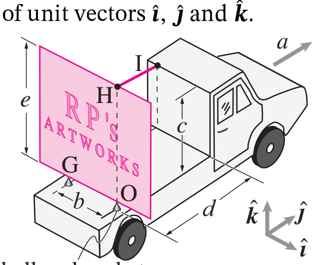
Problem 2.3.21

2.3.22 Hanging a shelf. A shelf with negligible mass supports a 0.5 kgmass at its center. The shelf is supported at one corner with a ball and socket joint and the other three corners with strings. Draw a FBD of the shelf.



Problem 2.3.22

2.3.23 Billboard in the back of a truck. Draw a free-body diagram of the billboard sitting in the back of the truck. There are ball and socket joints at G and O. IH is a rod. Write all forces shown on your diagram as appropriate vectors in terms of unit vectors $\hat{\boldsymbol{\imath}}$, $\hat{\boldsymbol{\jmath}}$ and $\hat{\boldsymbol{k}}$.



Problem 2.3.23