Problems

1. Given the following position vectors and forces, compute the following **vector products**:

$\underline{\boldsymbol{a}}$ = (35.0, 20.0) cm $\underline{\boldsymbol{b}}$ = (–10.00, 30.0) cm $\underline{\boldsymbol{c}}$ = (1.250, 2.50) m
$\underline{\boldsymbol{D}}$ = (50.0, 80.0) N $\underline{\boldsymbol{E}}$ = (–30.0, 20.0) N $\underline{\boldsymbol{F}}$ = (85.0, –50.0) N

(a) $\underline{\boldsymbol{a}} \times \underline{\boldsymbol{D}}$ (b) $\underline{\boldsymbol{a}} \times \underline{\boldsymbol{E}}$
(c) $\underline{\boldsymbol{b}} \times (\underline{\boldsymbol{D}} + \underline{\boldsymbol{E}})$ (d) $[\underline{\boldsymbol{b}} \times \underline{\boldsymbol{E}}]_z$
(e) $[\underline{\boldsymbol{c}} \times \underline{\boldsymbol{F}}]_z$ (f) $\underline{\boldsymbol{b}} \times \underline{\boldsymbol{F}}$

2. Given the following position vectors and forces, compute the following **vector products**:

$\underline{\boldsymbol{a}}$ = (30.0, 40.0) cm $\underline{\boldsymbol{b}}$ = (–5.00, 12.0) cm $\underline{\boldsymbol{c}}$ = (2.5, 5.85) m
$\underline{\boldsymbol{D}}$ = (24.6, 68.7) N $\underline{\boldsymbol{E}}$ = (–70.0, 50.0) N $\underline{\boldsymbol{F}}$ = (35.0, –200.) N

(a) $\underline{\boldsymbol{a}} \times \underline{\boldsymbol{D}}$ (b) $\underline{\boldsymbol{a}} \times \underline{\boldsymbol{E}}$
(c) $\underline{\boldsymbol{b}} \times (\underline{\boldsymbol{D}} + \underline{\boldsymbol{E}})$ (d) $[\underline{\boldsymbol{b}} \times \underline{\boldsymbol{E}}]_z$
(e) $[\underline{\boldsymbol{c}} \times \underline{\boldsymbol{F}}]_z$ (f) $\underline{\boldsymbol{b}} \times \underline{\boldsymbol{F}}$

3. A force's point of application is located at the coordinates (13.66, 20.5) cm. If the force's magnitude is 56.3 newtons and its direction is 34.3 degrees to the right horizontal what will its **moment of force** be about an axis through the origin.

4. A force's point of application is located at the coordinates (25.6, 10.45) cm. If the force's magnitude is 125.3 newtons and its direction is 64.3 degrees to the right horizontal what will its **moment of force** be about an axis through the origin.

5. Calculate the **moments of force** produced by a force with components (25.0, 35.0) newtons about the origin when its points of application are:
(a) (4.00, 8.00) cm   (b) (–4.00, 8.00) cm
(c) (4.00, –8.00) cm   (d) (–4.00, –8.00) cm

6. Calculate the **moments of a force** produced by a horizontal force of 66.0 newtons about the origin when its points of application are:
(a) (–15.00, 20.0) cm   (b) (0.00, 20.0) cm
(c) (15.00, 20.0) cm   (d) (150.0, 20.0) cm

7. Compute the **height** of the centre of gravity of a 60.0 kg person who is lying supine on a 2.00 m “reaction board” if the feet are at one end and the scale reading at the other end is 300 N. Assume that the weight of the board has been subtracted from the scale reading.

8. When the person mentioned above raises one leg and both arms, **where** is the centre of gravity if the new scale reading is 350 N?

9. Make a free-body diagram of the leg and foot (i.e., as one segment) for the situation depicted in figure 3.34 (person standing of a constant speed, moving, walkway). Write out the scalar equations of motion. Assume that the ground reaction force ($\underline{\boldsymbol{F}}_g$) is known and its point of application is at ($\boldsymbol{x_g}$, $\boldsymbol{y_g}$).

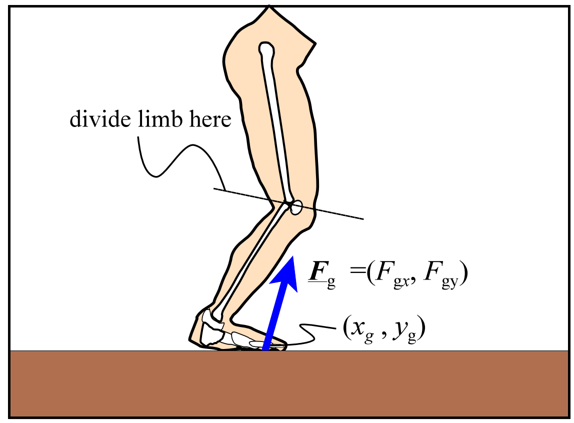

Figure 3.34 Lower extremity during push-off in walking

10. Draw a free-body diagram of person pulling a car with a rope attached to the bumper. Include only the person in the free-body.

11. Draw a free-body diagram of a person sitting motionless on a swing.

12. Draw a free-body diagram of a drywaller holding a piece of drywall overhead.

13. Draw a free-body diagram of a sprinter in the “marks” and “set” positions.

14. Draw a free-body diagram of a typist seated at a computer workstation so that you could compute the forces at the L5-S1 vertebral level.

15. What is the **tensile force** in the still ring cables when an 80.0 kg athlete performs a “support” position (arms at side)? Assume that the athlete is motionless and that the two cables are oriented vertically.

16. From problem 15 above, assume the gymnast is in an “iron-cross” position. Draw a free-body diagram and calculate the **force moment** at one shoulder joint caused by the force at the hand, where the distance between the shoulder and the hand is 75.0 cm. Use only the frontal view.

17. Give three examples of simple human activities in which a **mechanical advantage** is at work. Name three human movements in which a **speed advantage** is an essential element.

18. From figure 3.35, calculate the height (distance) of the person's centre of gravity above her feet when
    $\boldsymbol{L}$ = 2.00 m,
    $\boldsymbol{W}$ = 65.0 kg and
    $\boldsymbol{F_A}$ = 30.0 kg

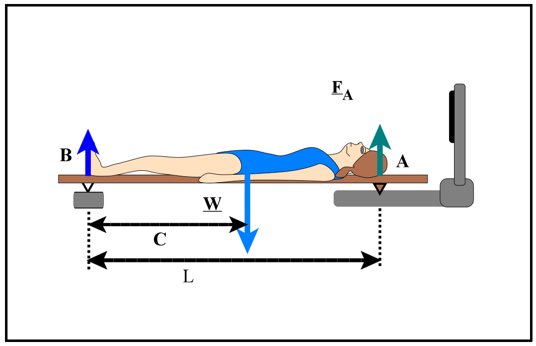

Figure 3.35 Question 18

19. Draw a free-body diagram of:
    (a) a swimmer in the "grab" start position
    (b) a worker lifting a box from the floor
    (c) a person performing a correct pushup
    (d) an athlete performing a free weight curl-up

20. Give example muscles of each class of lever (1, 2 and 3) that are not mentioned in the text. Show the relative locations of the fulcrum, load and force.

21. Determine the components of $\underline{\boldsymbol{F_2}}$ necessary to keep the rigid body in figure 3.36 in equilibrium.

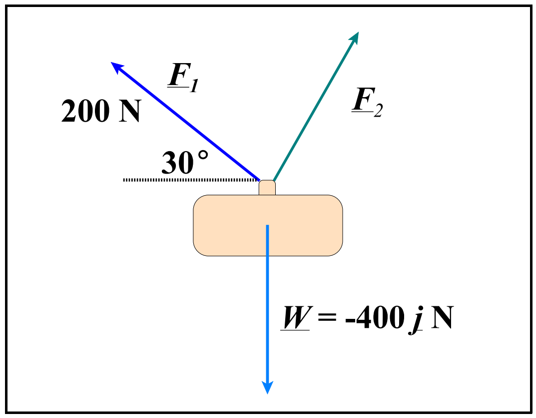

Figure 3.36 Question 21

22. What is the **knee moment of force** required for static equilibrium in figure 3.37? (Hint, solve for moments about an axis through the knee joint centre of rotation.)

23. What are the **components** of the reaction force at the knee joint for figure 3.37 assuming the lower leg is in static equilibrium and no other forces are acting?

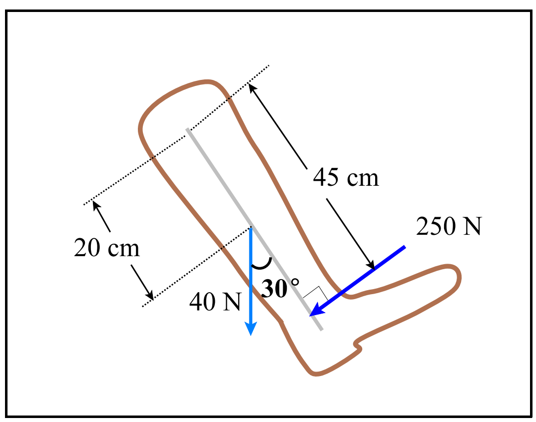

Figure 3.37 Questions 22 and 23

24. (Advanced) What classes of lever are the:
(a) shoulder abductors (deltoids),
(b) knee flexors (hamstrings),
(c) back extensors (erector spinae),
(d) jaw flexors during biting (masseter muscle),
(e) finger flexors (flexors digitorum superficialis muscles) and
(f) neck extensors (upper trapezius).