ORTHOLETTER

A Newsletter on Orthopaedic Technology in Developing Countries

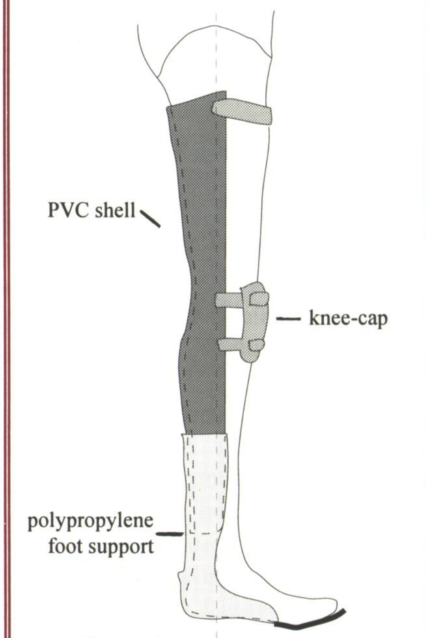
Number 5

In this issue:

Thermoplastic technology:

Low-cost PVC/polypropylene orthosis

In Pondicherry, India, low-cost calipers for polio children are manufactured in thermoplastic materials. PVC shells and polypropylene foot supports are prefabricated and adjusted to the child's leg at the time of fitting. To avoid long prescription processes and the risk of the child developing contractures, Multipurpose Rehabilitation Technicians with knowledge of physiotherapy have been introduced. .... **page 2**



The PVC/polypropylene orthosis

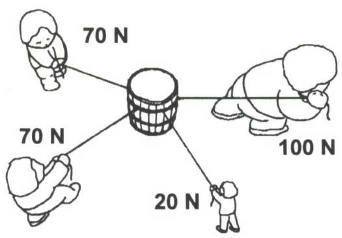
Lower limb prostheses for all levels of amputation

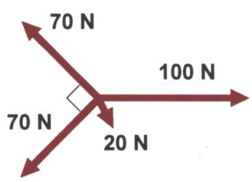
In Lokichokio, Kenya, polypropylene prostheses are produced for all levels of amputation. .... **page 6**

Biomechanics in Prosthetics and Orthotics (3)

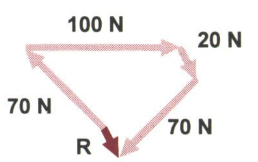
In this part of *Biomechanics in Prosthetics and Orthotics*, the *second condition for equilibrium* will be introduced. Before that, however, we will have to learn what is a *moment of force*. ....**page 7**

Solution to the mechanics problem presented in the last issue:

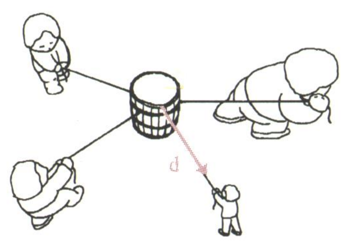




The forces as seen from above (Scale: 1 cm = 50 N)



Finding the resultant with the polygon method. (R = 20 N)



Clarification: To know in which direction the barrel will move, we have to determine the resultant of the four forces. (The *resultant* is the simplest force that can produce the same effect on the object as all the forces acting together.) To do this, the polygon method is used. The outcome may be a little surprising because we find that the resultant has the same direction and magnitude (20 N) as the force produced by the *smallest* boy (!), which means that the barrel will move in his direction (d). In fact, if it was not for him, the barrel would not move at all since the other three forces completely neutralise each other (their resultant is zero).

Next issue:

Community Based Rehabilitation (CBR) - an introduction

Educational Training in Cambodia

Biomechanics in Prosthetics and Orthotics (3)

Moment of force

If two boys of equal weight are to balance one another on a see-saw, they must sit at the same distance from the centre of the board (figure 1). However, if an *adult* wishes to balance with a boy, the boy will have to sit further from the centre than the adult. If the boy's weight is half that of the adult, the boy will have to sit twice as far from the centre. If his weight is only one third, he will have to sit three times as far back, and so on (figure 2). The weight of a person sitting on a see-saw has a turning effect on the see-saw board - it tends to rotate it. As we could see in the examples above, the magnitude of the turning effect depends on two factors; the size of the force (a heavy person tends to turn the board more than a light one) and the distance from the force to the turning point (the further from the centre the person sits, the higher the turning effect). In mechanics, the turning effect is usually referred to as the **moment of force** or simply the **moment**. The moment of force may be calculated by multiplying the *force* by the (perpendicular) *distance* from the force to the turning point. This is usually written M = F x d (where 'M' is the moment, 'F' the force and 'd' the distance) (figure 3). The moment is usually said to be positive when it has a clockwise turning effect and negative when the effect is directed counter-clockwise (figure 4). Since a moment of force is the product of a force and a distance, the SI unit of moments is the Nm (newton-metre). On the far right are three examples of how moments of force may be calculated.

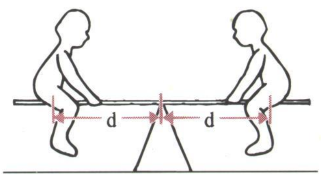


Figure 1. To balance each other, two boys of equal weight must sit at the same distance (d) from the centre.

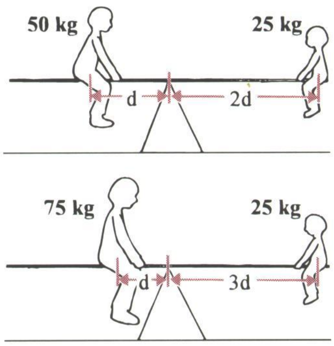


Figure 2. The boy must sit further from the centre to balance an adult.

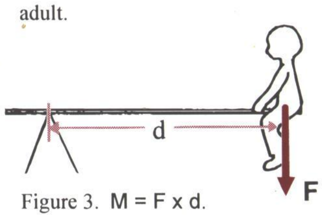


Figure 3. M = F x d.

Figure 4. The force F_1 has a *clockwise* turning effect on the board. Such a moment is usually said to be positive. The turning effect of F_2 is directed *counter-clockwise* and, correspondingly, the moment is said to be negative.

Example 1: A boy is balancing a small sack on a stick (figure 5). What is the moment of force exerted by the sack about the shoulder of the boy? (The shoulder is the turning point of the stick.)

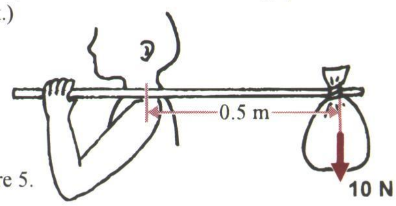


Figure 5.

M = F x d = 10 x 0.5 = 5

The moment of force is 5 Nm.

Example 2: A lady is carrying a bag on her forearm (figure 6). What is the moment of force exerted by the bag about the elbow? (The elbow joint is the turning point of the forearm).

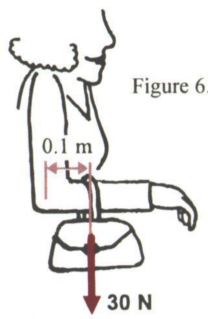


Figure 6.

M = F x d = 30 x 0.1 = 3

The moment of force is 3 Nm.

Example 3: What would be the moment of force if the lady in the previous example was carrying the bag in her hand instead of on her forearm (figure 7) ? (The elbow joint is still the turning point).

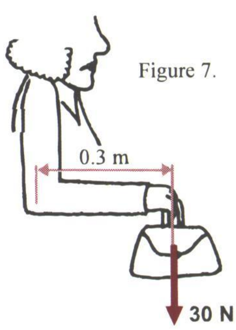


Figure 7.

M = F x d = 30 x 0.3 = 9

The moment of force is 9 Nm.

Note that in the third example, the moment of force is three times as high as in the previous one. This is because the distance is three times as great. (The result corresponds very well to our everyday experience; with a bent arm, it feels heavier to carry an object in the hand than on the forearm close to the elbow.)

Second condition for equilibrium

We have previously been introduced to the *first condition for equilibrium*, which states that if an object is at rest, the sum of the forces acting on it must be equal to zero **($\Sigma F = 0$)**. There are situations, however, where an object may not be at rest though the first condition of equilibrium is fulfilled. Let us, for example, make the following experiment; put ORTHOLETTER on a table in front of you. Grasp the upper right corner of the newsletter with your right hand and the lower left corner with your left hand (figure 8). Then pull the corners straight to the sides, i.e. to the right side with your right hand and to the left with your left hand, using the same force in both directions (figure 9). Though the forces are equal in magnitude and opposite in direction (meaning that $\Sigma F = 0$), the object is obviously not any more in equilibrium but tends to rotate (figure 10). Apparently, the first condition alone is not enough to describe the state of equilibrium but there is also need for a second condition.

The *second condition for equilibrium* states that if an object is at rest, the sum of the *moments* acting on the object must be equal to zero:

$$\Sigma M = 0$$

The sum of the moments of force may be determined about *any chosen point*; if the sum is zero about one point it is bound to be zero about any other point.

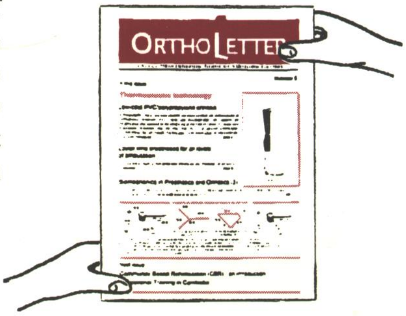


Figure 8. Hold the upper right corner of the newsletter with your right hand and the lower left corner with your left hand.

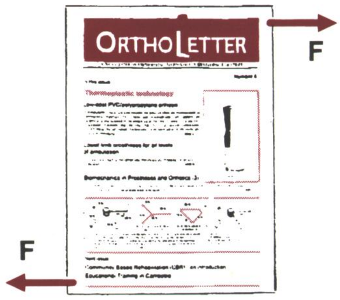


Figure 9. Pull the corners straight to the sides, using the same force (F) in both directions.

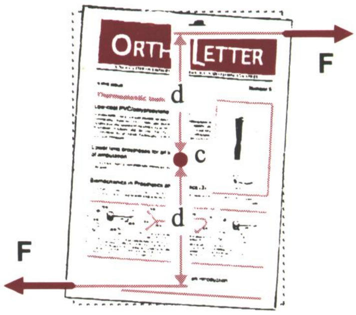


Figure 10. The forces, since parallel and not acting along the same line, produce two equal moments ($M = F \times d$), both of which rotate the object clockwise about its centre (c). Though the first condition for equilibrium is fulfilled, the object is not at rest.

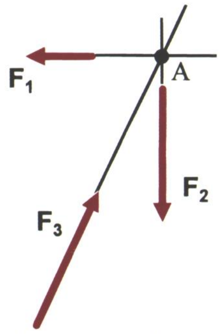


Figure 11. A concurrent force system. Since the forces are all acting through the same point (A), none of them will produce a moment about this particular point ($d = 0$ for all forces).

We may, finally, refer to the problem that was solved in the last section on *Biomechanics in Prosthetics and Orthotics* and the statement that the second condition for equilibrium would not have influenced the solution of that particular problem since the forces that were acting on the tug-of-war competitor formed a *concurrent force system*. Now we know enough mechanics to see why that is so; according to the definition of a concurrent force system, all forces are acting through the same point. If we choose this particular point (the point of intersection) as turning point, the distance to the point will be zero for all forces ($d = 0$). Then no one force will produce a turning moment around the point (figure 11). Consequently, the sum of the moments will be equal to zero and the condition fulfilled. (This is also true of *linear force systems* since they, in fact, are special cases of a concurrent force system; forces acting through the same line may also be said to act through the same point.)

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WORLD HEALTH ORGANIZATION

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