Question 1: All blue numbers are measured in Kilograms. Note: “20N Mass” should be “20N Weight”.

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| **Q1.m** |
| close all;    im1 = imread('Abduction30.png');  im2 = imread('Abduction60.png');  im3 = imread('Abduction90.png');  im4 = imread('Abduction120.png');    imcenter = [130 107;  164 129;  197 84;  171 88];    abductionAngle = [30 60 90 120];  massHeld = [0 20/9.81];    for i = 1:2  for j = 1:4  disp(['Forces for abduction angle of ' num2str(abductionAngle(j)) ' degrees']);  % weight, height, massHeld, armAngle, armCOMtoFdeltAngle, FdeltDistToJoint  [Fdelt, Fjx, Fjy, angle] =...  ShoulderForces(77, 190, massHeld(i), abductionAngle(j), 7.5, 7.5);    figure;  %subplot(2, 4, j+4\*(i-1));  switch j  case 1  imshow(im1); hold;  case 2  imshow(im2); hold;  case 3  imshow(im3); hold;  case 4  imshow(im4); hold;  end    if (i == 1)  title('No Mass');  else  title('20N Mass');  end    arrow(imcenter(j, :)-[Fjx Fjy]/norm([Fjx, Fjy])\*100, imcenter(j, :),...  'EdgeColor', 'r', 'FaceColor', 'r');  text(imcenter(j,1)+10, imcenter(j,2)+10, num2str(norm([Fjx, Fjy])), 'color', 'b');    disp(' ');  end  end |
| **ShoulderForces.m** |
| function [ Fdelta, Fjx, Fjy, angle ] = ShoulderForces( weight, height,...  massHeld, armAngle, armCOMtoFdeltAngle, FdeltDistToJoint)    format compact  syms Fdelta;    %weight = 77; % kg  %height = 190; % cm    armLength = (0.818 - 0.377)\*height  armCOM = 0.53 \* armLength  armSegmentWeight = 0.05\*weight    %armAngle = 30 % degrees    armMomentAngle = 90-armAngle  %armCOMtoFdeltAngle = 7.5    paperToBodyRatio = 3    % sum of moments to solve for fDelta;  syms Fdelt;    jointToFdeltLength = FdeltDistToJoint/10\*paperToBodyRatio % cm    moments = (0 == Fdelt\*jointToFdeltLength -...  (armSegmentWeight\*cos(degtorad(armMomentAngle))\*armCOM + ...  massHeld\*cos(degtorad(armMomentAngle))\*armLength));    Fdelt = double(solve(moments))    Fjy = (armSegmentWeight+massHeld) - Fdelt\*cos(degtorad(armAngle - armCOMtoFdeltAngle))  Fjx = -Fdelt\*sin(degtorad(armAngle - armCOMtoFdeltAngle))    angle = radtodeg(atan2(Fjy, Fjx));  if (angle < 0)  angle = 360 + angle;  end  angle    end |

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| **Output** | | |
| **Abduction Angle** | **No Mass** | **20N Weight** |
| 30 | Fdelt =  37.9941  Fjy =  -31.2520  Fjx =  -14.5397  angle =  245.0502 | Fdelt =  75.9554  Fjy =  -64.2849  Fjx =  -29.0669  angle =  245.6696 |
| 60 | Fdelt =  65.8077  Fjy =  -36.2112  Fjx =  -52.2088  angle =  214.7446 | Fdelt =  131.5586  Fjy =  -74.1990  Fjx =  -104.3724  angle =  215.4093 |
| 90 | Fdelt =  75.9882  Fjy =  -6.0685  Fjx =  -75.3381  angle =  184.6052 | Fdelt =  151.9107  Fjy =  -13.9396  Fjx =  -150.6111  angle =  185.2879 |
| 120 | Fdelt =  65.8077  Fjy =  29.0335  Fjx =  -60.7984  angle =  154.4738 | Fdelt =  131.5586  Fjy =  56.2340  Fjx =  -121.5443  angle =  155.1718 |

The paper *In Vivo Hip Joint Loading during Post-Operative Physiotherapeutic Exercises* [1] seeks to establish whether post-surgery physiotherapy exercises pose a threat to the healing process. While movement early after the surgery is beneficial to the healing process, just how much force, and whether full weight bearing is safe to apply, remains a question. Too much repetitive force from micromotions may “impair long-term fixation” [1], thereby reducing the lifetime of the implant. The study involved six patients ages , body mass Kg, and height cm who had undergone hip endoprostheses. Through embedded sensors, peak forces were measured during 13 common physiotherapy exercises for one-year post surgery.

The loads measured fit into three categories: Resultant contact force, torsional moment, and the bending moment. Through the exercises, readings were averaged, first for each patient and then for all patients, to produce an ‘activity-specific’ time pattern for the forces. In the post analysis, patients were grouped into ‘active’ and ‘passive’ categories. Those who were active showed higher forces in some activities, and similar forces for others when compared to the passive group. Overall, there were no noticeable differences in active vs. passive patients. The contraction intensity observed during isometric exercises were subject more to the patient’s motivation, and instruction by physiotherapist, instead of muscle strength. Factually, the highest load activities were those that were weight bearing, as opposed to resistance or lever-arm activities. Through these latter activities, forces were compensated with large torsional moments, as opposed to direct force on the joint.

Some post-operation movement, such as using a bed pan caused high joint loads, which are unavoidable. Thus, in developing a physiotherapy routine, eliminating high-load activities would not be possible. Therefore, it is important for the physician to decide carefully between partial and full weight exercises. For all such exercises, they should be developed using the loads observed during walking as a baseline.

# References

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| [1] | P. D. A. B. J. r. D. F. G. Verena Schwachmeyer, "In Vivo Hip Joint Loading during Post-Operative Physiotherapeutic Exercises," *PLOS One.* |