# Matlab Appendix

### Q12-13-14

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| %% Brachistochrone problem q.12  n = 500;  g = 9.8;  [X, Y] = meshgrid(1:n, 1:n);  n\_y = 1./sqrt(2 \* g \* Y);      %% Q12    x0 = [1, 1];%xy  x1 = [300, 300];%xy  S0 = 0;  S = runFSM(nref,x0,S0);    close all;  figure(1);  imagesc(S);axis square;    hold on; plot(x0(1),x0(2),'sb');  hold on; plot(x1(1),x1(2),'sk');    %% Q13  [Gx, Gy] = gradient(S);  alpha\_k = 0.9;    %iterate  xOld = inf(length(x0'), 1);  x = x1';%starting from end point working back to initial position  path = x1';  maxIter = 10000;  tol = 1e-6;  f = @(x)(interp2(X, Y, S, x(1), x(2)));  for k = 1:maxIter,  dx = -interp2(X, Y, Gx, x(1), x(2), 'linear', 0);  dy = -interp2(X, Y, Gy, x(1), x(2), 'linear', 0);  d = [dx; dy];    if (norm(x-xOld)<tol\*norm(xOld) || norm(x-x0') < 1 )  break;  end  %constant step size  alpha\_k = 0.1 / norm(d);  %update  xOld = x;  x = x + alpha\_k\*d;  path = [path x];    hold on; plot([xOld(1); x(1)], [xOld(2); x(2)], '-b', 'LineWidth', 2);    end    %% Q14 - analytic solution  %x = 0.5\*k^2\*(t - sin(t))  %y = 0.5\*k^2\*(1 - cos(t))  syms k t0 t1  %find k and t1  sol = solve(0.5\*k^2\*(t1 - sin(t1)) == x1(1), 0.5\*k^2\*(1 - cos(t1)) == x1(2));  kk = double(sol.k);    t = linspace(0, double(sol.t1), 1000);  x = 0.5\*kk^2\*(t - sin(t));  y = 0.5\*kk^2\*(1 - cos(t));    hold on;  plot(x, y, 'r'); |

### Q17

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| % q17  close all  clear all    load('I.mat');    figure;  imagesc(I);  axis image  colormap gray  title('Shaded image')    eps = 1E-10;  F = sqrt(1./I.^2 - 1 );  Fe = F + eps \* (F == 0);    x0 = [121, 143];  z0 = 0;  z = runFSM(Fe,x0,z0);    z = -z;  z = (z - min(z(:)))/(max(z(:)) - min(z(:)));    figure;  surf(z);  colormap gray  shading interp;  axis('tight');  view(110,45);  axis('off');  camlight  title('|\nablaz|=F(x,y)') |

### Q18-19

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| %% Q18 - Surface normals    load Images.mat  load LightSources.mat  load mozart.mat    I = double(Images);  L = double(LightSources);  %N - number of pictures  [rows, cols, N] = size(I);  Image\_n = zeros(rows, cols, 3);    Lpinv = pinv(L);  for n = 1:cols,  for m = 1:rows,  Imn = squeeze(I(m, n, :));  Image\_n(m, n, :) = Lpinv\*Imn;  end  end    %find p, q, N = (-p, -q, 1)  p = -Image\_n(:, :, 1)./((Image\_n(:, :, 3)) + eps);  q = -Image\_n(:, :, 2)./((Image\_n(:, :, 3)) + eps);      %% Q19 - Jacobi method  rows\_p2 = rows + 2;  cols\_p2 = cols + 2;  size = rows\_p2\*cols\_p2;  R = CreateDelOperators(rows\_p2, cols\_p2);%  dd = -full(sum(R, 2));  D = spdiags(dd, 0, size, size);  invD = spdiags(1./dd, 0, size, size);  [Dx, Dy] = CreateDerivativeOperators(rows\_p2, cols\_p2);    p = padarray(p, [1 1]);  q = padarray(q, [1 1]);  px = Dx\*p(:);  qy = Dy\*q(:);    A = R + D;  b = px + qy;    x0 = zeros(size, 1);  k\_max = 50000;  tol = 1e-1;    x = x0;  k = 1;  % x = A\b;  while( norm(A\*x-b) > tol && k <= k\_max )  x = invD\*(b-R\*x);  k = k + 1;  end    Z = reshape(x, [rows\_p2 cols\_p2]);    figure;  colormap gray;  surf(Z,'FaceColor','interp',...  'EdgeColor','none')  axis tight  shading interp  view(110,45)  camlight left;  axis off  title('Estimated Depth image')    figure;  colormap gray;  surf(mozart,'FaceColor','interp',...  'EdgeColor','none',...  'FaceLighting','gouraud')  axis tight  shading interp  view(110,45)  camlight left;  axis off  title('Ground Truth') |

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| %% Q20    Q17  Q18    close all;  figure;  subplot(1, 2, 1);  surf(z);  colormap gray  shading interp;  axis('tight');  view(110,45);  axis('off');  camlight  title('|\nablaz|=F(x,y)')  subplot(1, 2, 2);  surf(Z);  colormap gray  shading interp;  axis('tight');  view(110,45);  axis('off');  camlight  title('|\nabla^2z|=p\_x + q\_y') |