1 Moorish

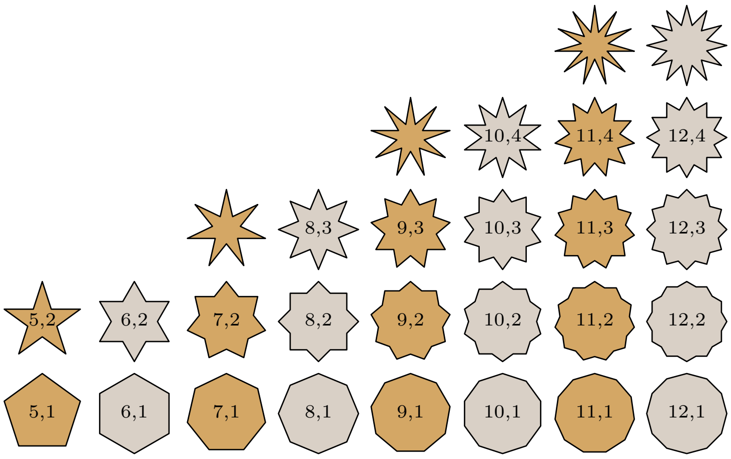
These designs are largely taken from the chapter on Moorish tiling patterns in Owen Jones' *Grammar of Ornament*, 1856. The section names are all mine. Each file inputs `jones-colors.mp`, which defines the six colours used as follows:

⬜	`ivory = 1/256 (218, 209, 199);`
⬛	`navy = 1/256 (57, 62, 81);`
🟫	`gold = 1/256 (213, 168, 101);`
⬛	`forest = 1/256 (68, 93, 105);`
🟦	`lapiz = 1/256 (45, 53, 166);`
🟪	`plum = 1/256(72, 59, 85);`

Many of the patterns use regular polygonal stars, which are drawn by this macro:

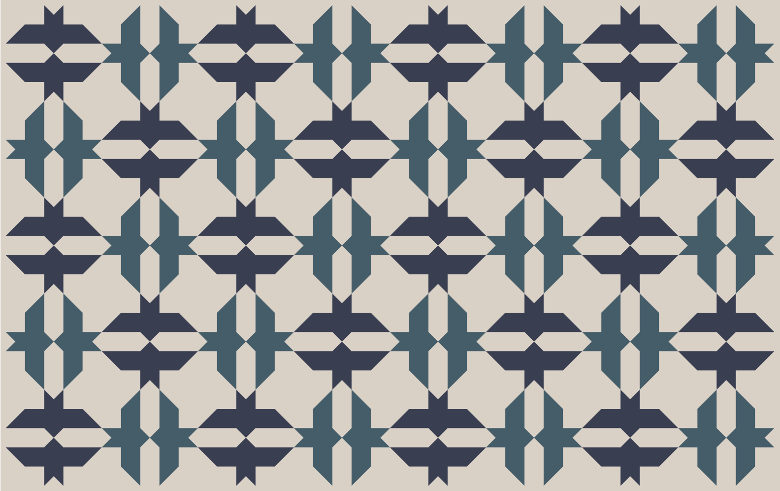
```
vardef star(expr n, s, r) =
  save a, b, t; path a, b; numeric t;
  a = (up -- up rotated (360/n*s)) scaled r;
  b = a rotated -(360/n*(s-1));
  (t,whatever) = a intersectiontimes b;
  for i=0 upto n-1: subpath (0, t) of a rotated (360/n*i) -- endfor cycle
enddef;
```

The parameter r is the radius of the star; n and s determine the shape, like this:



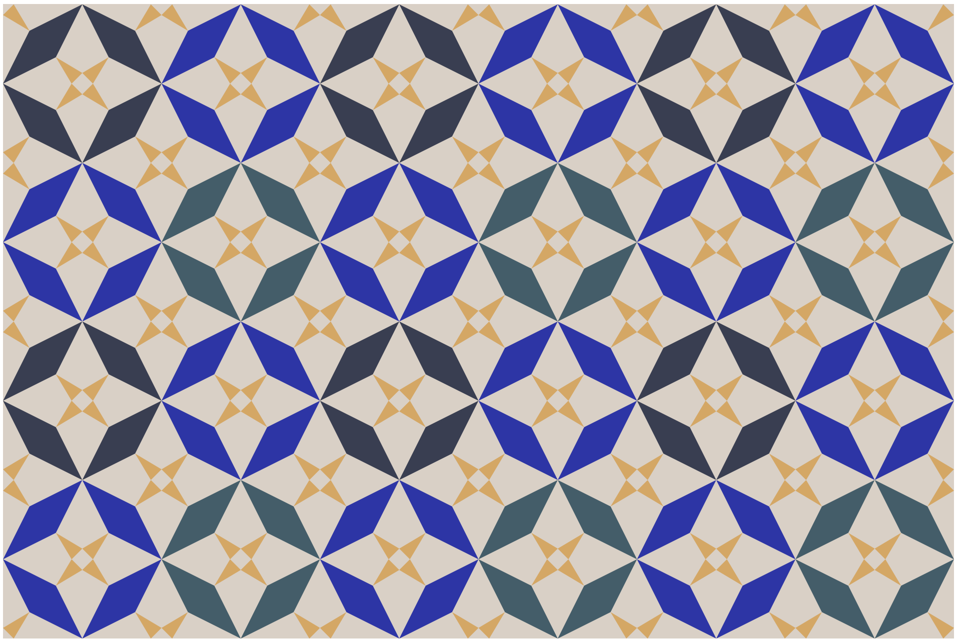
Most of the patterns in the following pages are laid out on a square grid, but the last three use a triangular grid.

Bats



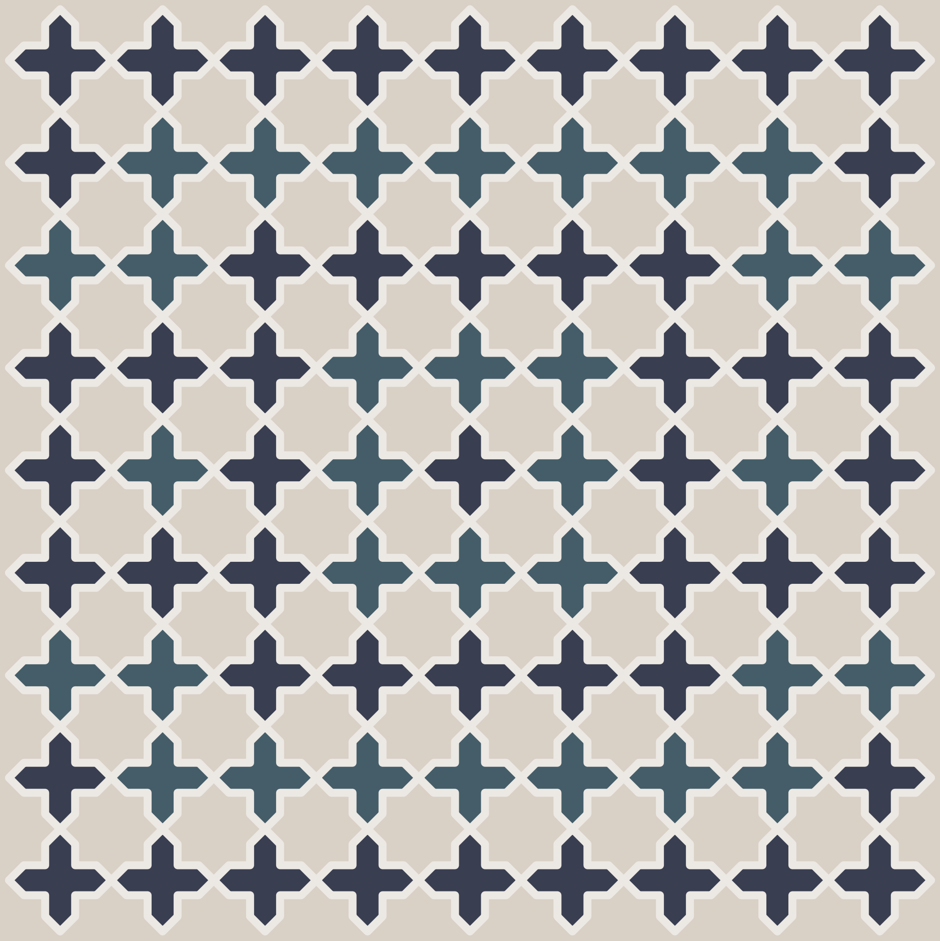
```
beginfig(1);
  path bat;
  bat = (0,0)--(1,1)--(5,1)--(3,3)--(1,3)--(1,5)--(0,4)--
        (-1,5)--(-1,3)--(-3,3)--(-5,1)--(-1,1)--cycle;
  vardef unit(expr shade) = image(for t=0, 180:
    fill bat scaled 3.6 rotated t withcolor shade;
  endfor) enddef;
  picture tile[]; tile0 = unit(navy); tile1 = unit(forest) rotated 90;
  numeric u, v; (u,v) = urcorner tile0 - llcorner tile0;
  for i=1 upto 8:
    for j=1 upto 5:
      draw tile[(i+j) mod 2] shifted (i*u,j*v);
    endfor
  endfor
  picture p; p = currentpicture; fill bbox p withcolor ivory; draw p;
endfig;
```

Carré



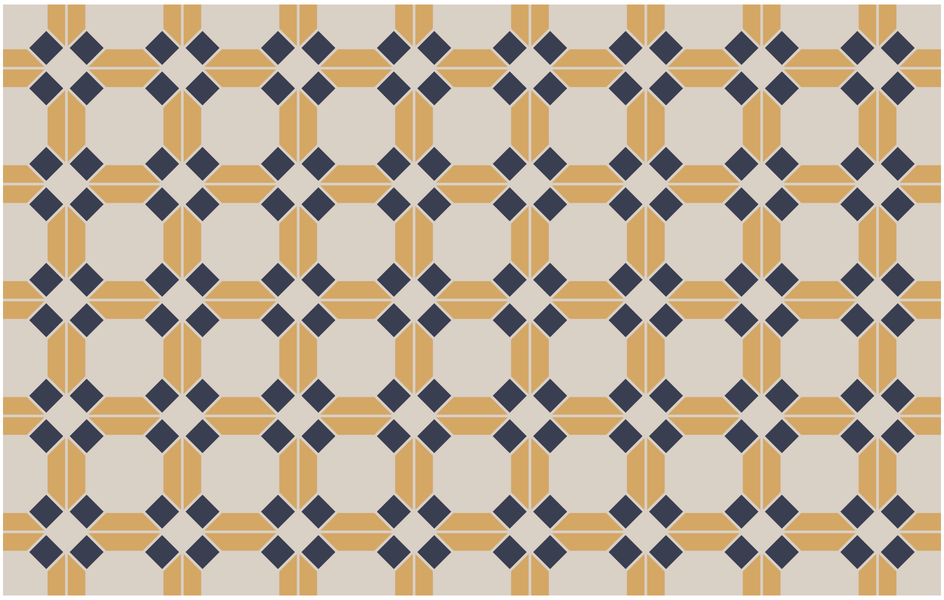
```
beginfig(1);
  path lozenge, triangle, box;
  lozenge = (left -- down -- right -- up -- cycle)
    yscaled 1/3 rotated -45 scaled 21;
  interim bboxmargin := 0; box = bbox lozenge;
  triangle = point 0 of box + 4 right -- point 1 of lozenge
          -- point 0 of box + 4 up -- cycle;

  vardef paint_tile(expr s) = image(
    fill box withcolor ivory;
    fill triangle withcolor gold;
    fill triangle rotated 180 withcolor gold;
    fill lozenge withcolor s;
  ) enddef;

  picture tile[];
  tile0 = paint_tile(lapiz);   tile2 = paint_tile(navy);
  tile1 = paint_tile(forest);  tile3 = paint_tile(lapiz);

  (u, v) = urcorner tile0 - llcorner tile0;
  for i = 0 upto 11:
    for j = 0 upto 7:
      t := (floor (i/2) mod 2) + 2(floor (j/2) mod 2);
      draw tile[t] if odd (i+j): rotated 90 fi shifted (i*u, j*v);
    endfor
  endfor
endfig;
```

Cross



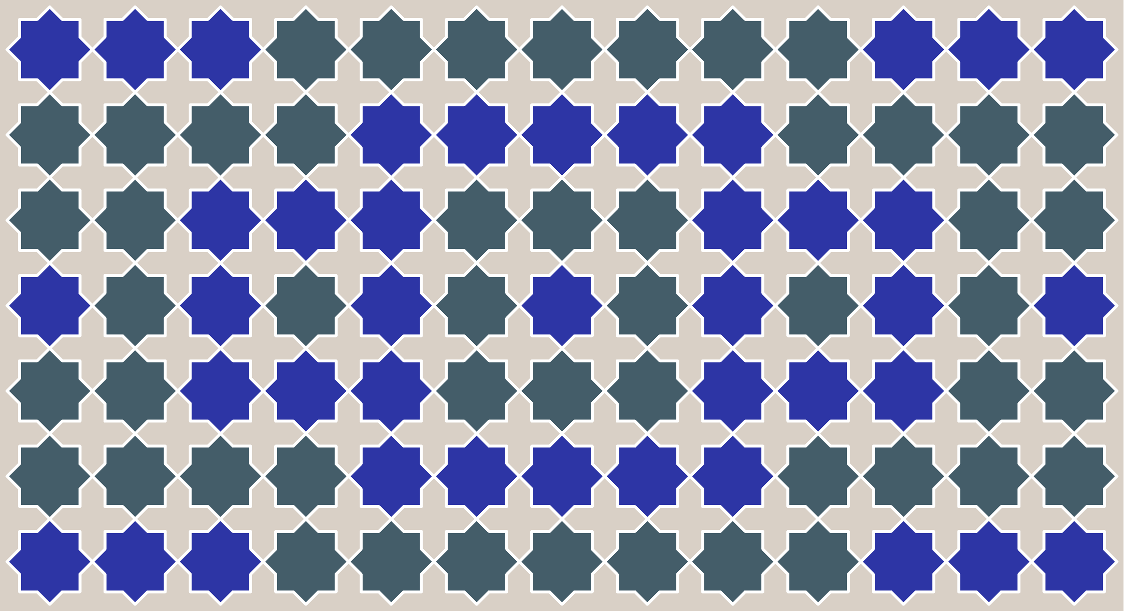
```
beginfig(1);
  path cross;
  numeric r, t; t = 2; r = t-sqrt(2);
  cross = (for i=0 upto 3:
    ((t,0) -- (t-r, r) -- (r, r) -- (r, t-r)) rotated 90i --
  endfor cycle) scaled 9.6;

  pair u, v;
  u = point 0 of cross - point 8 of cross;
  v = point 4 of cross - point 12 of cross;
  n = 4;
  for i=-n upto n:
    for j=-n upto n:
      k := j + floor ((i + abs(j)) / (2 abs(j) + 1));
      fill cross shifted (i*u+j*v)
        withcolor if odd k: forest else: navy fi;
      draw cross shifted (i*u+j*v)
        withpen pencircle scaled 3 withcolor 1/2[ivory, white];
    endfor
  endfor
  picture P; P = currentpicture; fill bbox P withcolor ivory; draw P;
endfig;
```

Lifebelt



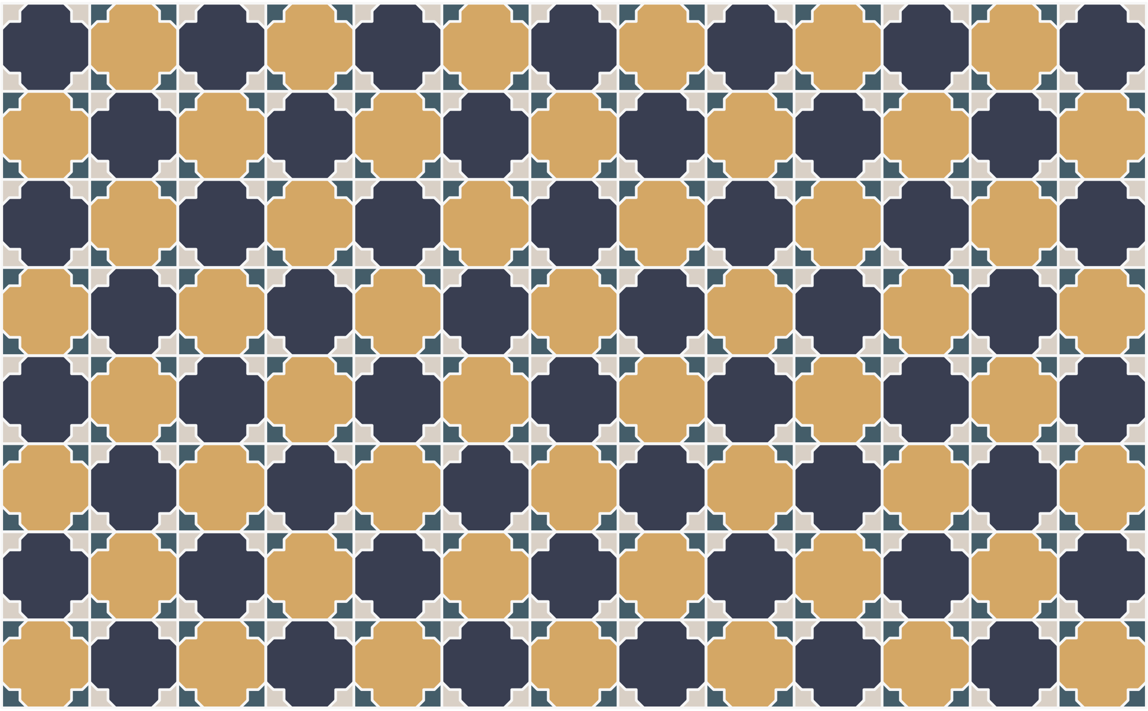
```
beginfig(1);
  background := ivory;
  numeric u; u = 10;
  path s; s = unitsquare scaled u shifted 1/2(3u, -u) rotated 45;
  path t; t = subpath (2,3) of s -- subpath (0,1) of s rotated 90 -- cycle;
  picture unit; unit = image(
    pickup pencircle scaled 1;
    for i=0 upto 3:
      fill s rotated 90i withcolor navy;
      fill t rotated 90i withcolor gold;
    endfor
    for i=0 upto 3:
      undraw s rotated 90i;
      undraw subpath (1,2) of t rotated 90i;
    endfor
    pickup defaultpen;
  );
  numeric u, v; (u,v) = urcorner unit - llcorner unit;
  for i=0 upto 8:
    for j= 0 upto 5:
      draw unit shifted (i*u, j*v);
    endfor
  endfor
  picture P; P = currentpicture; unfill bbox P; draw P;
  begingroup;  interim bboxmargin := -1/2 u;
  clip currentpicture to bbox currentpicture;
  endgroup;
endfig;
```

Octa-star



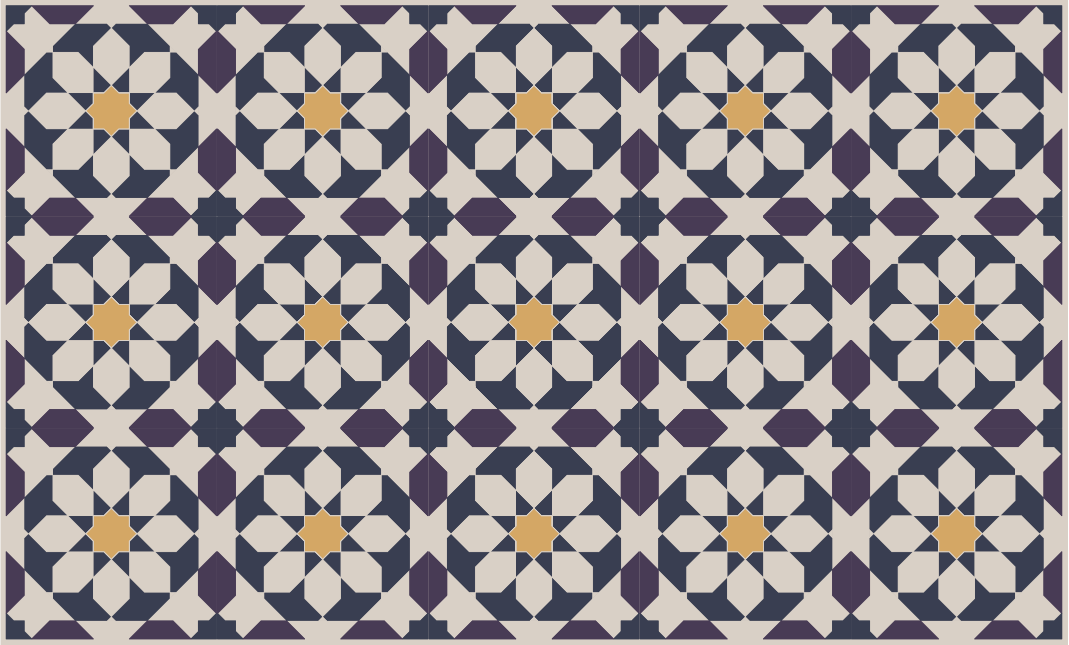
```
beginfig(1);
  background := ivory;
  path cross; cross = star(8,2,16);
  numeric u, v; (u, v) = urcorner cross - llcorner cross;
  for i=-6 upto 6:
    for j=-3 upto 3:
      pair z; z = (i*u, j*v);
      numeric k; k = j + floor ((i + abs j) / (1 + 2 abs j));
      fill cross shifted z withcolor if odd k: forest else: lapiz fi;
      draw cross shifted z withpen pencircle scaled 1 withcolor white;
    endfor
  endfor
  picture P; P = currentpicture; unfill bbox P; draw P;
endfig;
```

Quad



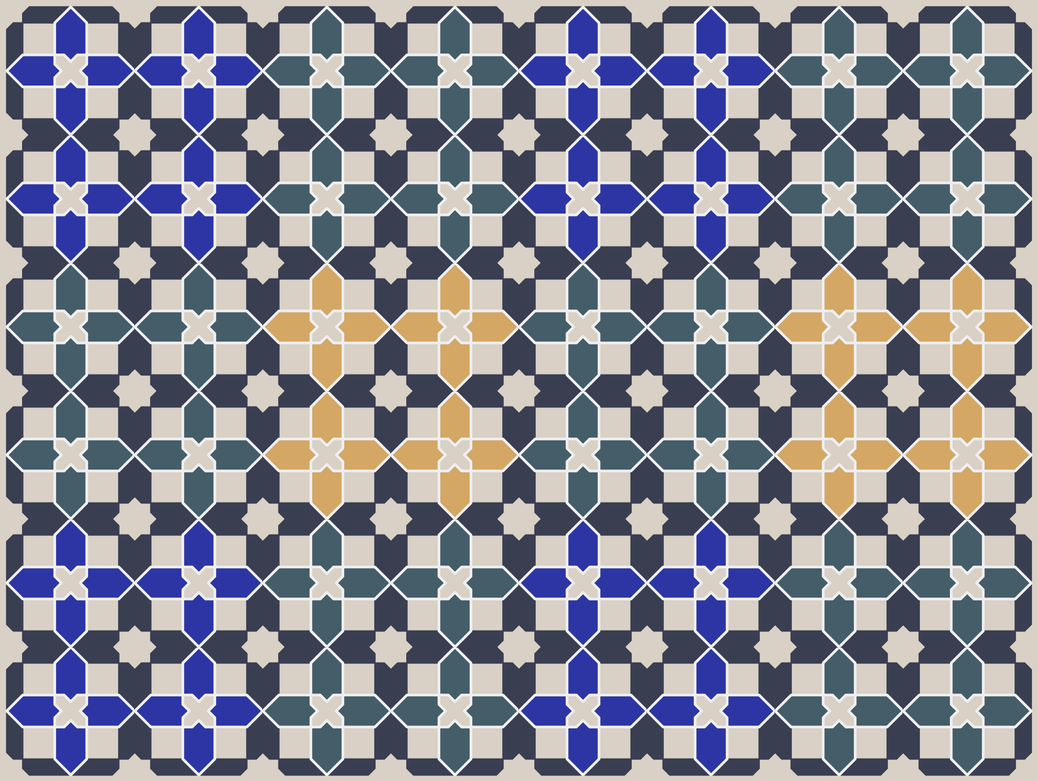
```
beginfig(1);
  numeric u, r; u = 33; r = sqrt(1/2);
  path s; s = unitsquare shifted -(1/2, 1/2) scaled u;
  path o; o = for i=0 upto 7: point r of s rotated 45i -- endfor cycle;
  path c; c = for i=0 upto 3:
    (subpath (0, 1-r) of o --
    point 0 of o rotatedabout(point 1 of s, -45) --
    subpath (r, 1) of o) rotated 90i --
  endfor cycle;

  vardef tile(expr fg, bg) = image(
    fill s withcolor bg;
    fill c withcolor fg;
    draw s withpen pencircle scaled 1 withcolor 31/32;
    draw c withpen pencircle scaled 1 withcolor 31/32;
  ) enddef;

  for i=1 upto 13:
    for j=1 upto 8:
      draw if odd (i+j):
        tile(navy, ivory)
      else:
        tile(gold, forest)
      fi shifted (i*u, j*u);
    endfor
  endfor
endfig;
```

Rosette



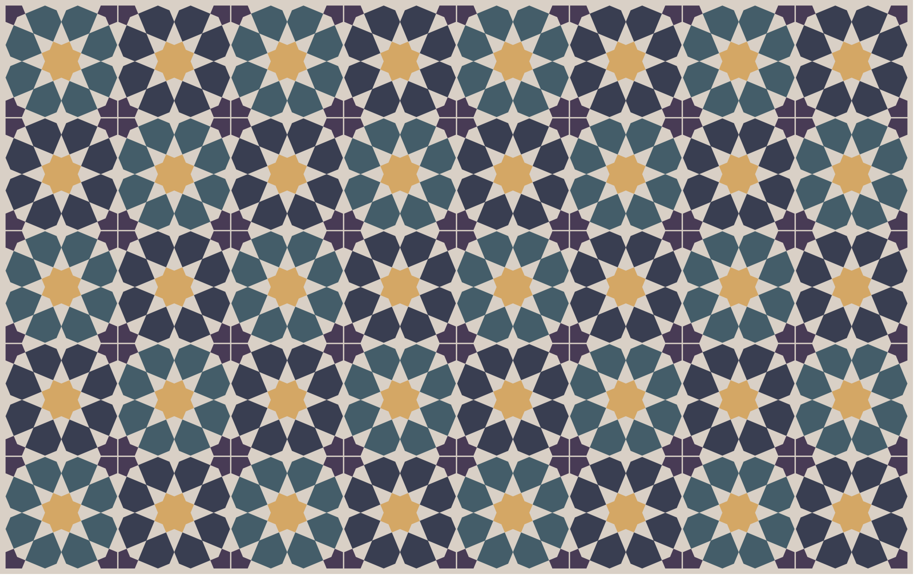
```
beginfig(1);
  background := ivory;
  path o; o = for i=0 upto 7: 48 dir (45i + 45/2) -- endfor cycle;
  fill o withcolor navy;
  numeric r, s; r = 3; s = 13; pair q; q = (s,s) scaled sqrt(1/2);
  path t; t = (up -- origin -- right) scaled s;
  path u; u = (down * s -- up * r -- right * r -- left * s);
  path leaf; leaf = t shifted q --
                    u shifted (point 1/2 of o - 1/2(r,r)) -- cycle;
  for i=0 upto 7:
    unfilldraw leaf rotated 45i withpen pencircle scaled 1/4;
  endfor
  path v; v = star(8,2,s); % common star macro
  fill v withcolor gold; undraw v;
  path w; w = (origin -- subpath(4,8) of v -- cycle)
              shifted (xpart point 0 of o, ypart point 1 of o) shifted q;
  path p; p = point 0 of o -- point 5 of w shifted (q rotated 180) --
              point 5 of w -- point 0 of o shifted (q rotated -90) -- cycle;
  for i=0 upto 3:
    filldraw w rotated 90i withcolor navy;
    filldraw p rotated 90i withcolor plum;
    filldraw p reflectedabout(left, right) rotated 90i withcolor plum;
  endfor

  picture unit; unit = currentpicture; clearit;
  numeric u, v; (u,v) = urcorner unit - llcorner unit;
  for i=1 upto 5: for j = 1 upto 3:
    draw unit shifted (i*u, j*v);
  endfor endfor
  picture P; P = currentpicture; clearit;
  P := P scaled (396 / xpart (urcorner P - llcorner P));
  unfill bbox P; draw P;
endfig;
```

Scotch



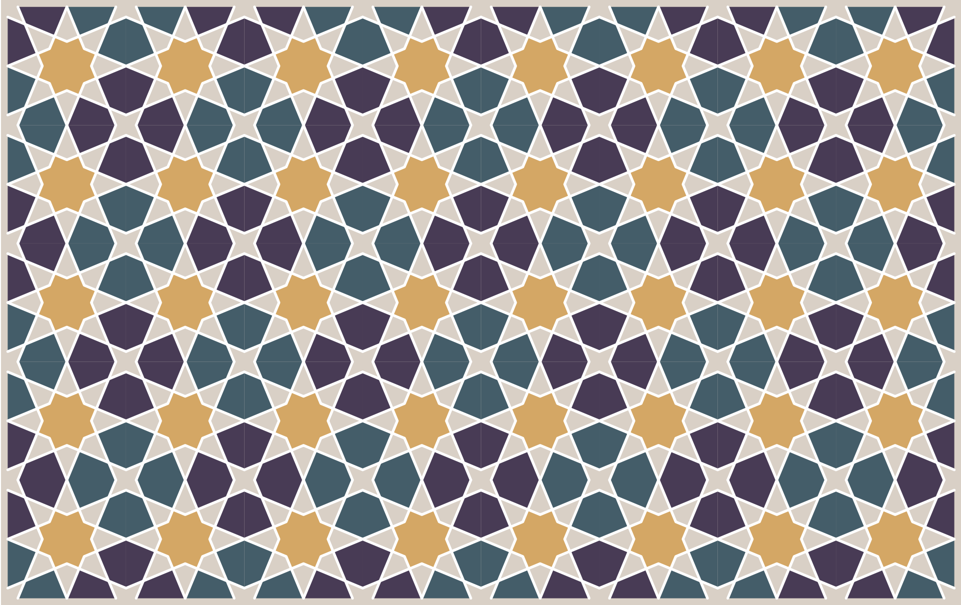
```
beginfig(1);
  background := ivory;
  numeric r; r = sqrt(2)-1;
  path s; s = (0, r-1) -- (r, -1) -- (1, -1) -- (1, -3) -- (0, -4);
  path t; t = (0, -4) -- (1, -3) -- (3, -3) -- (3, r-4) -- (3-r, -4);
  s := s -- subpath (3,1) of s reflectedabout(up, down) -- cycle;
  t := t -- subpath (4,1) of t reflectedabout(up, down) -- cycle;

  numeric u; 4u = 24;
  s := s scaled u;
  t := t scaled u;

  vardef unit(expr shade) = image(for i=0 upto 3:
    filldraw t rotated 90i withcolor navy;
    fill s rotated 90i withcolor shade;
    draw s rotated 90i withpen pencircle scaled 1 withcolor 15/16;
  endfor) enddef;

  for i=2 upto 9:
    for j=2 upto 7:
      color shade; shade =
      if odd floor(i/2): if odd floor(j/2): lapiz else: forest fi
                   else: if odd floor(j/2): forest else: gold fi fi;
      draw unit(shade) shifted ((i, j) scaled 8u);
    endfor
  endfor

  picture P; P = currentpicture;clearit; unfill bbox P; draw P;
endfig;
```

Star-flower



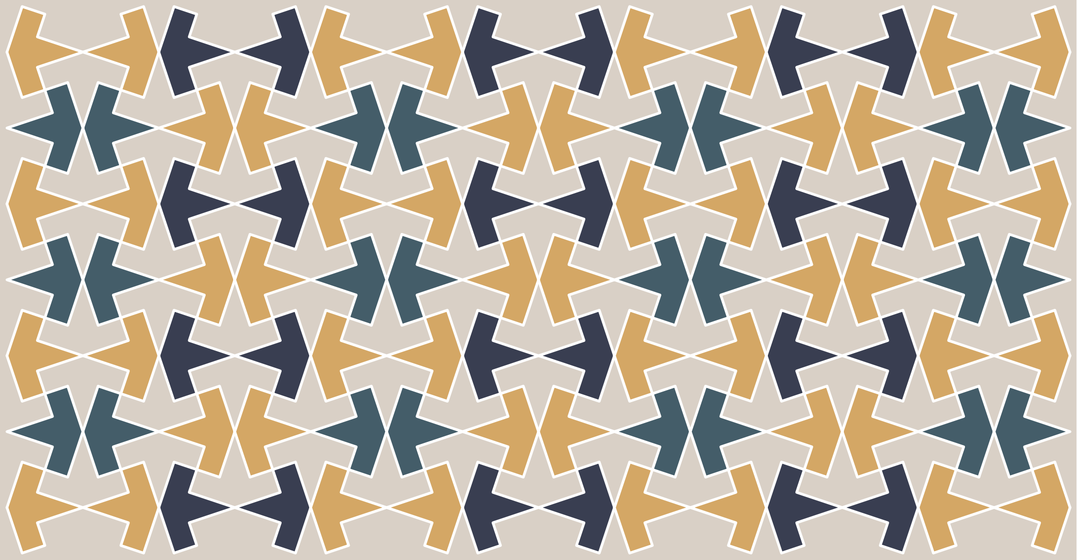
```
beginfig(1);
  background := ivory;
  path s, t, a, b;
  s = star(8, 2, 8) rotated -45/2;  % the common star macro
  z0 = whatever[point  4 of s, point  0 of s]
     = whatever[point 14 of s, point 10 of s];
  t = (origin -- subpath (-3, 1) of s -- cycle) rotatedabout(z0, 180);
  z1 = whatever[point 2 of s, point 6 of s]
     = whatever[point 8 of s rotatedabout(z0, 180),
                                     point 12 of s rotatedabout(z0, 180)];
  a = point 0 of s -- z0 -- point 2 of t -- z0 rotatedabout(point 0 of t, -45)
      -- z1 -- z0 rotated 45 -- cycle;
  b = a reflectedabout(up, down);

  picture tile[]; numeric n; n = -1;
  forsuffixes $=forest, navy:
    tile[incr n] = image(
      fill s withcolor gold;
      for i=0 upto 3:
        fill t rotated 90i withcolor plum;
        fill a rotated 90i withcolor $;
        fill b rotated 90i withcolor $;
      endfor);
  endfor

  numeric u, v, grouting; grouting = 1/2;  % also try negative...
  (u-grouting, v-grouting) = urcorner tile0 - llcorner tile0;
  for i=1 upto 8:
    for j= 1 upto 5:
      draw tile[(i+j) mod 2] shifted (i*u, j*v);
    endfor
  endfor
  picture P; P = currentpicture; unfill bbox P; draw P;
endfig;
```

Sun



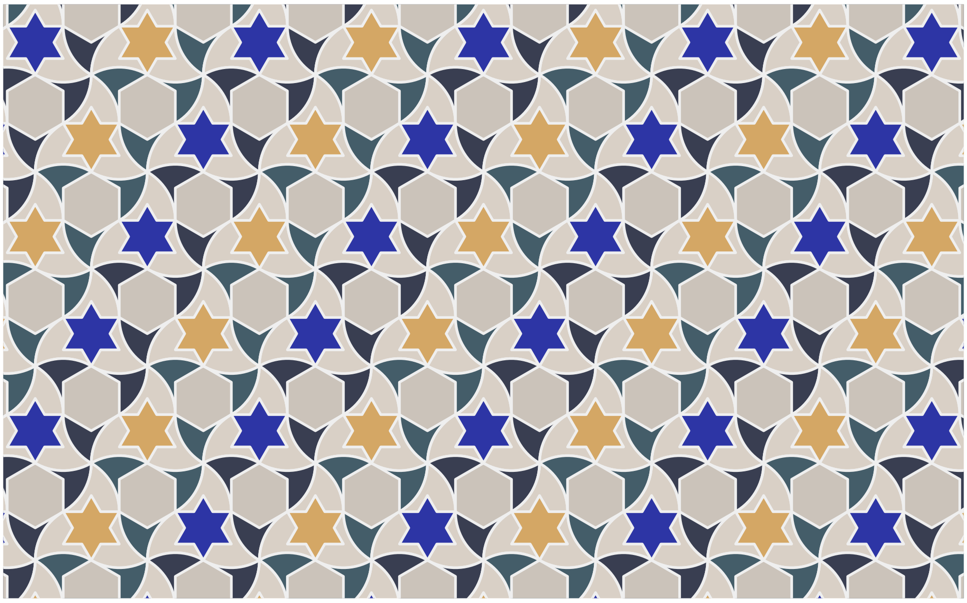
```
beginfig(1);
  background := ivory;
  path S, W, M; numeric a,b,c,d,e;
  S = star(8, 2, 12) rotated 45/2;  % the common star macro
  z0 = a[point 2 of S, point 14 of S] = b[point 4 of S, point 8 of S];
  z1 = c[point 6 of S, point 10 of S] = d[point 4 of S, point 0 of S];
  z2 = e[point 6 of S, point 10 of S]; x2=x0;
  W = z2 -- z1 -- point 4 of S -- z0 -- cycle;
  M = W reflectedabout(origin, dir 45);
  picture tile; tile = image(
    fill S withcolor gold;
    for i=0 upto 1:
      fill W rotated 180i withcolor forest;
      fill M rotated 180i withcolor forest;
      fill W rotated (90+180i) withcolor plum;
      fill M rotated (90+180i) withcolor plum;
    endfor
    drawoptions(withpen pencircle scaled 1 withcolor white);
      draw S;
      for i=0 upto 3:
        draw subpath (0, 3) of W rotated 90i;
        draw subpath (0, 3) of M rotated 90i;
      endfor
    drawoptions();
  );
  numeric u, v, grouting; grouting = -1;
  (u - grouting, v - grouting) = urcorner tile - llcorner tile;
  for i = 1 upto 8:
    for j = 1 upto 5:
      draw tile if odd (i+j): rotated 90 fi shifted (i*u, j*v);
    endfor
  endfor
  picture p; p = currentpicture; unfill bbox p; draw p;
endfig;
```

Tack



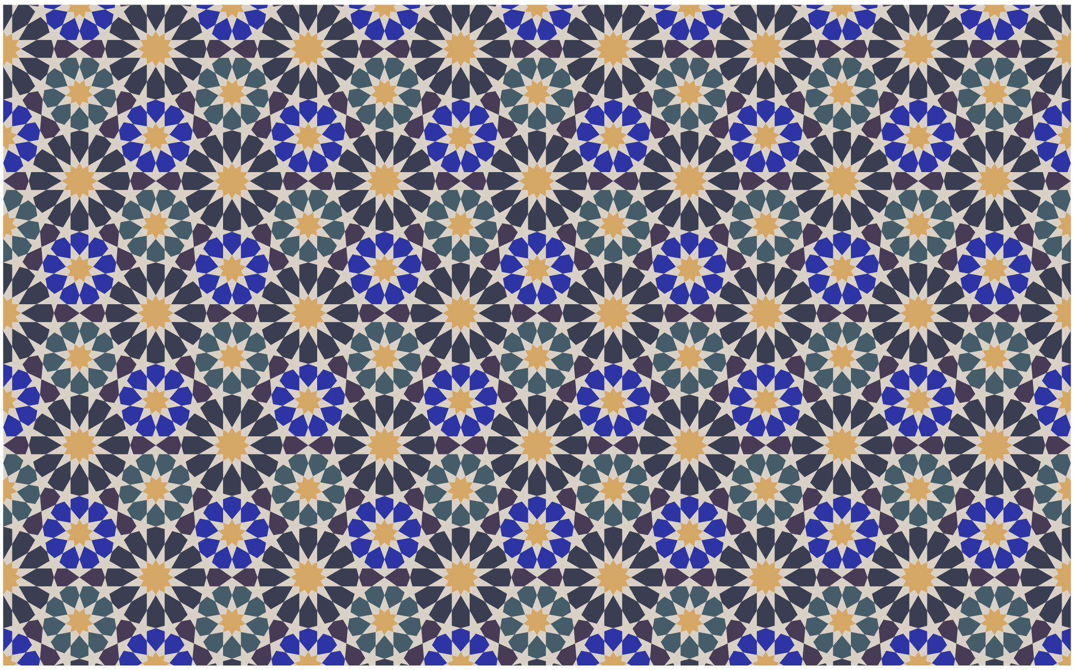
```
beginfig(1);
  path tack;
  tack = (0,0) -- (0,2) -- (1,2) -- (1,1) -- (3,1);
  tack := tack rotated - angle point 4 of tack;
  tack := tack shifted -1/2 point 4 of tack;
  tack := tack -- subpath (3,0) of tack reflectedabout(left, right) -- cycle;
  tack := tack scaled 9;

  pair u, v; u = point 4 of tack - point 0 of tack; v = u rotated 90;

  background := ivory;
  for i=2 upto 15:
    for j=0 upto 6:
      path t; t = tack rotated (180 ((i+j) mod 2));
      pair z; z = i*u + j*v;
      fill t shifted z withcolor
        if odd floor(i/2): if odd j: forest else: gold fi
                     else: if odd j: gold   else: navy fi fi;
      draw t shifted z withpen pencircle scaled 1 withcolor white;
    endfor
  endfor
  picture P; P = currentpicture; clearit; unfill bbox P; draw P;
endfig;
```

Hex-star



```
beginfig(1);
  numeric r; r = sqrt(1/3);
  path t; t = (r * dir   0 {dir  60} .. {dir 120} 2r * dir  60 {dir 240}
            .. r * dir 120 {dir 180} .. {dir 240} 2r * dir 180 {dir 360}
            .. r * dir 240 {dir 300} .. {dir 360} 2r * dir 300 {dir 120}
            .. cycle) rotated -30 scaled 21;
  numeric a; (a, whatever) = t intersectiontimes (origin -- infinity * up);
  path h; h = for i=0 upto 5: point a of t rotated 60i -- endfor cycle;
  path t'; t' = t rotatedabout(point 1 of t, 60);
  path h'; h' = h rotatedabout(point 1 of t, 60);
  path s; s = for i=0 upto 5:
    point i of h' -- 1/3[point i of h', point i+2 of h'] --
  endfor cycle;
  vardef unit(expr a, b) = image(
    fill t withcolor a; fill h withcolor 15/16 ivory;
    fill t' withcolor ivory; fill s withcolor b;
    drawoptions(withpen pencircle scaled 1 withcolor 15/16);
      draw t; draw t'; draw h; draw s;
    drawoptions();
  ) enddef;
  pair u, v; u = origin rotatedabout(point 1 of t, 120); v = u rotated -60;
  numeric n; n = 6;
  for i = -n upto n:
    for j = -n upto n:
      draw unit(if odd (i+j): navy else: forest fi,
        if odd (i+j): gold else: lapiz fi)
        shifted (i*u + j*v);
    endfor
  endfor
  clip currentpicture to unitsquare shifted -(1/2,1/2) scaled 5in yscaled 0.618;
endfig;
```

Twelve-and-nines



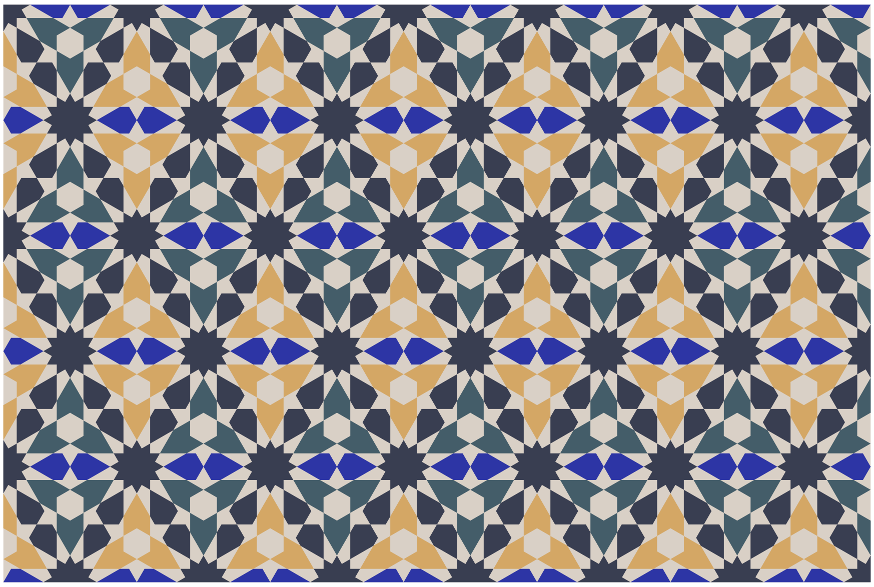
```
beginfig(1);
  numeric r[]; r0 = 19; r1 = 14;
  z0 = origin;
  z1 = (r0 + r1) * up;

  path t, n, m; % twelve-gon, and nine-gons
  t = (for i=0 upto 11: up rotated 30i -- endfor cycle) scaled r0 rotated -30;
  n = (for i=0 upto 8: down rotated 40i -- endfor cycle) scaled r1 shifted z1;
  m := n reflectedabout(origin, point 0 of t);
  z2 = z1 reflectedabout(origin, point 0 of t);

  path p; pair a, b, c, d, e;
  a = whatever[point 1 of n, point 2 of n] = whatever[point 0 of t, point 1 of t];
  b = whatever[point 1 of m, point 2 of m] = whatever[point 0 of t, point -1 of t];
  c = whatever[a, b rotated 180] = whatever[b rotated 30, a rotated 210];
  d = whatever[b, a rotated 180] = whatever[a rotated -30, b rotated 150];
  e = whatever[b rotated 30, a rotated 210]
    = whatever[a rotated -30, b rotated 150];
  p = (point 0 of t -- a -- c -- e -- d -- b -- cycle) rotated 30;
  for i=1 upto 12:
    fill p rotated 30i withcolor navy;
  endfor
  fill star(12, 4, abs point 3 of p) withcolor gold;
```

continued on next page ...

...from previous page

```
 path q, s; pair a, b, c, d, e;
 a = whatever[point 0 of n, point 1 of n] = whatever[point -1 of p, point -2 of p];
 b = whatever[point 0 of n, point -1 of n] = whatever[point 1 of p, point 2 of p];
 c = whatever[a, b rotatedabout(z1, 180)]
  = whatever[b rotatedabout(z1, 40), a rotatedabout(z1, 220)];
 d = whatever[b, a rotatedabout(z1, 180)]
  = whatever[a rotatedabout(z1, -40), b rotatedabout(z1, 140)];
 e = whatever[b rotatedabout(z1, 40), a rotatedabout(z1, 220)]
  = whatever[a rotatedabout(z1, -40), b rotatedabout(z1, 140)];
 q = point 0 of n -- a -- c -- e -- d -- b -- cycle;
 s = q rotated -60;

 for i=1 upto 9:
  fill q rotatedabout(z1, 40i) withcolor forest;
  fill s rotatedabout(z2, 40i) withcolor lapiz;
 endfor;
 fill star(9, 3, abs (point 3 of q - z1)) rotated 20 shifted z1 withcolor gold;
 fill star(9, 3, abs (point 3 of q - z1)) shifted z2 withcolor gold;

 path g; pair a;
 a = whatever[point 1 of n, point 2 of m] = whatever[point 1 of m, point 2 of n];
 g = subpath (-2, 2) of q rotated -30 -- a -- cycle;
 for i=-1 upto 1: for r=0, 180:
  fill g rotatedabout(a, r) rotated 60i withcolor plum;
 endfor endfor

 picture unit; unit = currentpicture; clearit;
 pair u, v; u = point 6 of m - point 3 of t; v = u rotated 60;
 for i=0 upto 7:
  for j=0 upto 5:
   draw unit shifted (i * u + j * v - floor(j/2) * u) ;
  endfor
 endfor

 background := ivory;
 picture P; P = currentpicture; unfill bbox P; draw P;
 clip currentpicture to unitsquare xscaled 7 xpart u yscaled 5 ypart v shifted z2;
endfig;
```

Twelve-pointers



```
beginfig(1);
  numeric u; u = 10;
  path s; s = star(12, 4, u);
  z0 = whatever[point 0 of s, point -8 of s]
     = whatever[point 2 of s, point 10 of s];
  path t; t = star(12, 5, abs z0) rotated 15;
  path h; h = star(6, 1, 2.5u) rotated 30;
  numeric a, b; (a, b) = h intersectiontimes
                    subpath(0,-1) of t rotatedabout(point 0 of t, 180);
  path p; p = subpath(0,2) of t -- subpath (6-a, a-6) of h -- cycle;
  path r; r = (subpath(6-a, a-6) of h)
              reflectedabout(point 2-a/3 of h, point a/3-2 of h) rotated 30;
  path q; q = subpath(2,4) of t -- r -- cycle;

  vardef paint_tile(expr a, b) = image(
    fill s withcolor navy;
    for i=0 upto 5:
      fill p rotated 60i withcolor if i mod 3 = 1: lapiz else: navy fi;
      fill q rotated 60i withcolor if i mod 3 = 2: a else: b fi;
    endfor
  ) enddef;
  picture rosette[];
  rosette0 = paint_tile(forest, gold);
  rosette1 = paint_tile(gold, forest);

  pair u, v; u = lrcorner rosette1 - llcorner rosette1; v = u rotated 60;
  for i=0 upto 7:
    for j=0 upto 5:
      draw rosette[j mod 2] shifted (i*u + j*v - floor(j/2)*u);
    endfor
  endfor
  picture P; P = currentpicture; fill bbox P withcolor ivory; draw P;
  clip currentpicture to
    unitsquare xscaled 13/2 xpart u yscaled 5 ypart v shifted 1/2 u;
endfig;
```