8-gVirtualXRay_vs_DRRs

March 25, 2022

[1]:
```
from IPython.display import display
from IPython.display import Image
import os
from utils import * # Code shared across more than one notebook
```

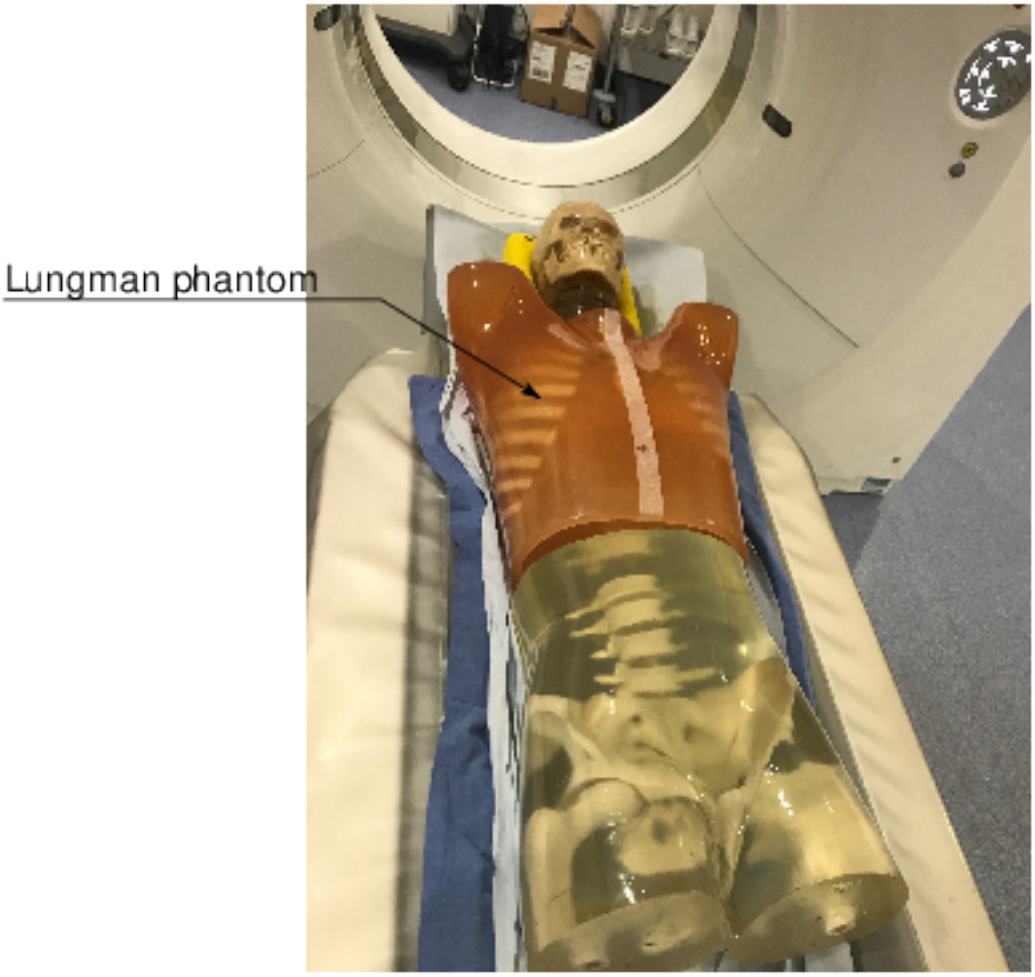
1 gVirtualXray vs DRRs

Main contributors: J. Pointon, J. Tugwell-Allsup and F. P. Vidal

Purpose: In this notebook, we aim to demonstrate that gVirtualXRay is able to generate analytic simulations on GPU comparable to digitally reconstructed radiographs (DRRs) of a real CT scan computed with Plastimatch.

Material and Methods: For this experiment, we attempt to recreate a X-ray projections of the Lungman chest phantom with gVirtualXRay.

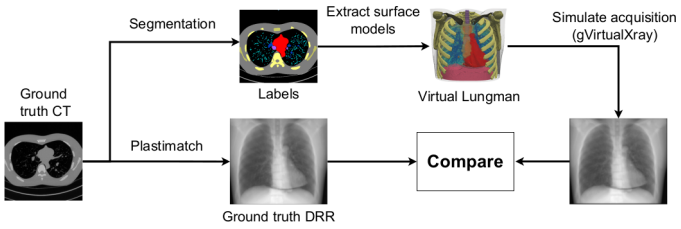
[2]:
```
display(Image("lungman_data/lungman.png"))
```



1. The CT of a chest phantom has been generated from a real scanner ahead of time.
2. Structures in the reference CT have been segmented and labelled.
3. The resultant surfaces from the segmentations form a virtual lungman model.
4. We use gVirtualXRay to simulate X-ray projection on this model and
5. compare the result with Digitally Reconstructed Radiographs (DRRs) of the original CT scan.

[3]:
```
Image("doc/lungman-validation-DRR-flow.png", width=800)
```

[3]:



Results: Images generated with gVirtualXray are very similar to DRRs computed with Plastimatch, despite the use of homogeneous materials in the simulation. MAPE is low in both cases (1.84% and 1.92%), ZNCC (99.61% and 99.83%) and SSIM (0.93 and 0.98) are high in both cases. It took 419 ms to compute the DRR images on GPU with Plastimatch compiled with CUDA, 37 ms with gVirtualXray. It corresponds to a 11x speedup.

[5]:
```
fname = "plots/lungman-profiles-CT-mu.png"
if os.path.exists(fname):
    display(Image(fname))
```

Quantitative comparisons
From qauntative measures we achieved: a ZNCC score of 0.977 (97.7% similarity), a MAPE/MAPD 0.293 and a SSIM score of 0.911. For reference, a good ZNCC and SSIM score is 1 and a good MAPE score is 0.

The calculations were performed on the following platform:

[6]:
```
printSystemInfo()
```

```
OS:
        Linux 5.3.18-150300.59.54-default
        x86_64

CPU:
        AMD Ryzen 7 3800XT 8-Core Processor

RAM:
        63 GB
GPU:
        Name: GeForce RTX 2080 Ti
        Drivers: 455.45.01
        Video memory: 11 GB
```

2 Import packages

[7]:
```
%matplotlib inline

import SimpleITK as sitk
import pandas as pd
import numpy as np
import numpy.ma as ma # Masking
from utils import *
from convertRaw import *
import gvxrPython3 as gvxr
import json2gvxr

import matplotlib
```

```
import matplotlib.pyplot as plt

font = {'family' : 'serif'#,
        #'weight' : 'bold',
         # 'size'   : 22
       }
matplotlib.rc('font', **font)
# matplotlib.rc('text', usetex=True)

from tifffile import imread, imwrite # Load/Write TIFF file

from sitk2vtk import *
from sklearn.metrics import mean_absolute_percentage_error as mape
from skimage.metrics import structural_similarity as ssim
import skimage

#import scipy
import os
import math
import zipfile
import datetime

import imageio

import k3d
import random
import base64
from stl import mesh
from time import sleep
```

```
SimpleGVXR 1.0.1 (2022-03-10T15:28:42) [Compiler: GNU g++] on Linux
gVirtualXRay core library (gvxr) 1.1.5 (2022-03-10T15:28:36) [Compiler: GNU g++]
on Linux
```

[8]:
```
SAVE_DATA = False
GENERATE_NEW_DATA_ALWAYS = True
DO_K3D_PLOT = True
```

[9]:
```
DO_ARTEFACT_FILTERING_ON_GPU = True
DO_ARTEFACT_FILTERING_ON_CPU = False
number_of_projections = 1000
angular_step = 180 / number_of_projections
```

3 Configure gVirtualXRay environment

3.1 Create an OpenGL context and window

[10]:
```
json2gvxr.initGVXR("notebook-8.json", "OPENGL")
```

```
Create an OpenGL context: 512x512
Thu Mar 24 21:12:54 2022 ---- Create window gvxrStatus: Create window
0


0 0 500 500
OpenGL renderer:   GeForce RTX 2080 Ti/PCIe/SSE2
OpenGL version:    3.2.0 NVIDIA 455.45.01
OpenGL vender:     NVIDIA Corporation
Thu Mar 24 21:12:54 2022 ---- Use OpenGL 4.5.0 0 512 512
```

3.2 Create a parallel photon beam

[11]:
```
json2gvxr.initSourceGeometry()
```

```
Set up the beam
        Source position: [0, -500, 0, 'mm']
        Source shape: ParallelBeam
```

3.3 Create a monochromatic spectrum

[12]:
```
json2gvxr.initSpectrum();
```

Create a detector array.

[13]:
```
json2gvxr.initDetector()
```

```
Set up the detector
        Detector position: [0, 500, 0, 'mm']
        Detector up vector: [0, 0, 1]
        Detector number of pixels: [725, 426]
        Pixel spacing: [0.625, 0.7, 'mm']
```

[14]:
```
nb_pixels = gvxr.getDetectorNumberOfPixels()
detector_size = gvxr.getDetectorSize("mm")
pixel_width = detector_size[0] / nb_pixels[0]
pixel_height = detector_size[1] / nb_pixels[1]
```

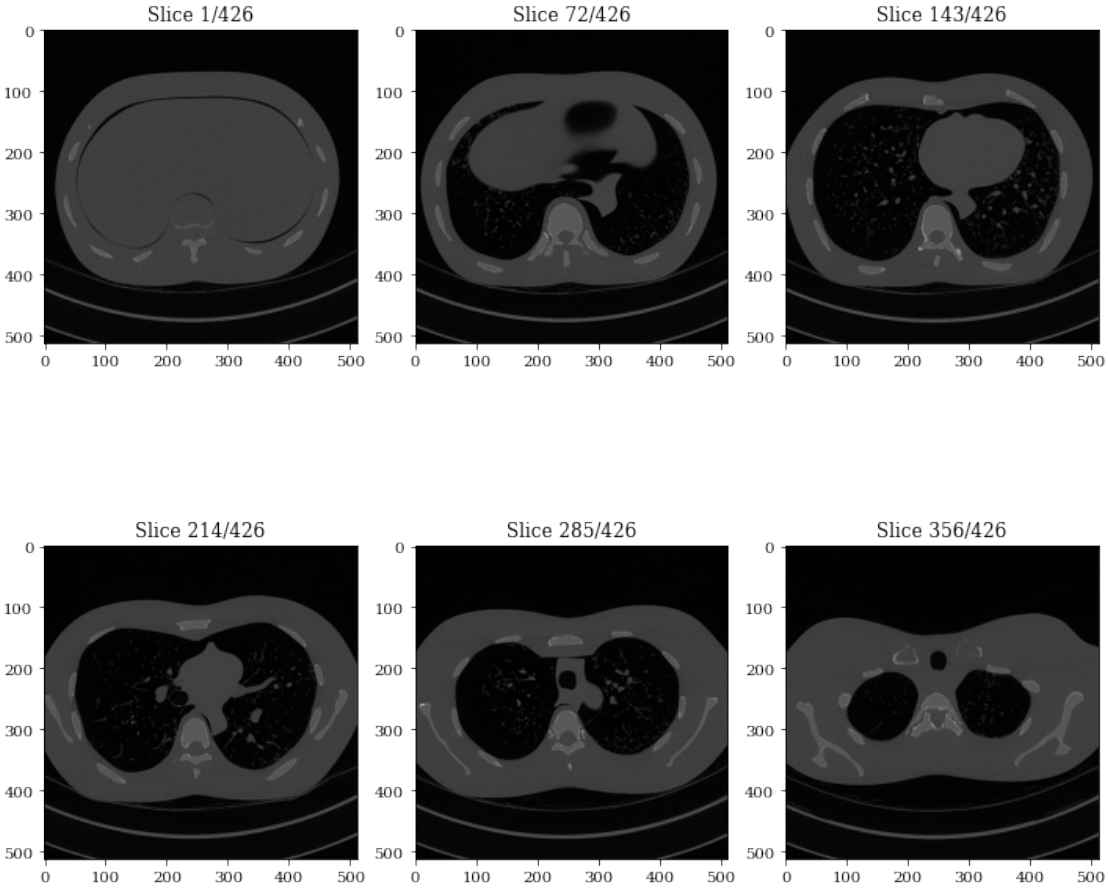
4 Load the CT scan

[15]:
```
# Read the reference CT
sitk_reader = sitk.ImageFileReader();
sitk_reader.SetImageIO("MetaImageIO");
sitk_reader.SetFileName("lungman_data/lungman.mha")
raw_ground_truth = sitk_reader.Execute()
real_CT_in_HU = np.array(sitk.GetArrayFromImage(raw_ground_truth));

#
# Blur using CurvatureFlowImageFilter
#
# blurFilter = sitk.CurvatureFlowImageFilter()
# blurFilter.SetNumberOfIterations(5)
# blurFilter.SetTimeStep(0.125)
# sitk_ground_truth_CT_recons_in_HU = blurFilter.Execute(raw_ground_truth)
# ground_truth_CT_recons_in_HU = np.array(sitk.
 ↪GetArrayFromImage(sitk_ground_truth_CT_recons_in_HU));

# Make sure each volume has floating point precision
real_CT_in_HU = real_CT_in_HU.astype(np.single);

# Drop the first and last slices
# ground_truth_CT_recons_in_HU = ground_truth_CT_recons_in_HU[1:
 ↪ground_truth_CT_recons_in_HU.shape[0] - 1]
```

```
Thu Mar 24 21:12:54 2022 ---- Initialise the renderer
```

[16]:
```
ncols = 3
nrows = 2

step = int(real_CT_in_HU.shape[0] / (ncols * nrows))
slices = range(0, int(real_CT_in_HU.shape[0]), step)

fig = plt.figure(figsize= (10,10))

ct_min_val = real_CT_in_HU.min()
ct_max_val = real_CT_in_HU.max()

for i in range(ncols):
    for j in range(nrows):
        index = j * ncols + i

        slice_id = slices[index]

        ax = fig.add_subplot(nrows, ncols, index + 1)
```

```
        ax.set_title("Slice " + str(slice_id + 1) + "/" + str(real_CT_in_HU.
↪shape[0]))
        ax.imshow(real_CT_in_HU[slice_id], cmap='gray', vmin=ct_min_val,␣
↪vmax=ct_max_val)

plt.tight_layout()

plt.savefig('plots/lungman-real_CT_in_HU.pdf')
plt.savefig('plots/lungman-real_CT_in_HU.png')
```



[17]:
```
def ShouldGenerateNew(*fnames):

    if (GENERATE_NEW_DATA_ALWAYS):
        return True

    for fname in fnames:
        if (not os.path.exists(fname)):
            return True
```

```
    return False
```

5 Convert ground truth from HU to Îij

[18]:
```
fname = "gVirtualXRay_output_data/lungman-real_CT_in_mu.mha"

if ShouldGenerateNew(fname):

    #real_CT_in_mu = np.array(gvxr.convertHU2mu(real_CT_in_HU, ray_energy,␣
 ↪"keV"))
    mu_air  =gvxr.getMuFromHU(-1000.0, 72, "keV");
    mu_water  =gvxr.getMuFromHU(0.0, 72, "keV");
    real_CT_in_HU = real_CT_in_HU.astype(np.double);
    real_CT_in_mu = ((real_CT_in_HU / 1000.0 ) * (mu_water - mu_air)) + mu_water;


    if SAVE_DATA:

        sitk_real_CT_in_mu = sitk.GetImageFromArray(real_CT_in_mu)
        sitk_real_CT_in_mu.SetSpacing([pixel_width, pixel_width, pixel_height])

        sitk_real_CT_in_mu.SetOrigin((-pixel_width * real_CT_in_mu.shape[2] / 2.
 ↪0,
                                -pixel_width * real_CT_in_mu.shape[1] / 2.0,
                                -pixel_height * real_CT_in_mu.shape[0] / 2.0))

        sitk.WriteImage(sitk_real_CT_in_mu, fname, useCompression=True)

else:
    sitk_real_CT_in_mu = sitk.ReadImage(fname)
    real_CT_in_mu = sitk.GetArrayFromImage(sitk_real_CT_in_mu)
```

6 Extract data for this experiment

The labelled volumes are provided compressed in a zip file. Use this procedure to extract the surfaces and masks needed for this notebook.

[19]:
```
# Uncompress the labels
if (False == os.path.isfile("./lungman_data/segmentation-uncompressed/labels.
 ↪mha")):
    with zipfile.ZipFile(  "./lungman_data/segmentation-compressed.zip", 'r') as␣
 ↪myzip:
        myzip.extractall(  "./lungman_data/segmentation-uncompressed")
```

```
# Read the records for isovalue, average HU
mapHandle = open("./lungman_data/segmentation-uncompressed/map.dat");
bytes = mapHandle.read();
split_lines = bytes.split('\n');
bytes = None;
mapHandle.close();

# Read labels
label_rel_path = "./lungman_data/segmentation-uncompressed/labels.mha";
phantom = sitk.ReadImage(label_rel_path)
phantom_array = sitk.GetArrayFromImage(phantom)
```

[20]:
```
# rd = vtk.vtkMetaImageReader();
# rd.SetFileName(label_rel_path);
# rd.Update()
# vtkLabels = rd.GetOutput();

# Create threshold filter
# threshold = vtk.vtkImageThreshold();
# threshold.SetInputData(vtkLabels);
# threshold.SetReplaceOut(0);
# threshold.ReplaceOutOn()
# threshold.ReplaceInOff();

fname_HU = "gVirtualXRay_output_data/lungman-ground_truth2-CT-in_HU.mha"
fname_mu = "gVirtualXRay_output_data/lungman-ground_truth2-CT-in_mu.mha"

ref_data = {}

if ShouldGenerateNew(fname_HU, fname_mu):
    digital_phatom_in_HU = np.zeros(phantom_array.shape, dtype=np.int16) - 1000
    digital_phatom_in_mu = np.zeros(phantom_array.shape, dtype=np.single)
else:
    sitk_digital_phatom_in_HU = sitk.ReadImage(fname_HU)
    digital_phatom_in_HU = sitk.GetArrayFromImage(sitk_digital_phatom_in_HU)

    sitk_digital_phatom_in_mu = sitk.ReadImage(fname_mu)
    digital_phatom_in_mu = sitk.GetArrayFromImage(sitk_digital_phatom_in_mu)

for i in range(0, len(split_lines)):

    tuple_parts = split_lines[i].split('\t');

    structure_name = tuple_parts[2][0:-4]
    structure_isovalue = int(tuple_parts[0])
```

```
    print("Process", structure_name)

    # See if the surface already exists
    stl_rel_path = "./lungman_data/meshes/" + tuple_parts[2][0:-4] + ".stl";
    # if (True == os.path.isfile(stl_rel_path)): continue;

    # Threshold to get label
#     threshold.ThresholdBetween(structure_isovalue, structure_isovalue);
#     threshold.Update();
#     vtkIm = threshold.GetOutput();

#     # Extract surface and save
#     vtkSurface = extractSurface(vtkIm, structure_isovalue);
#     writeSTL(vtkSurface, stl_rel_path);
#     vtkSurface = None;
#     vtkIm = None;

    # Threshold the phantom
    binary_mask = (phantom == structure_isovalue)

    # Pad the image
    filt = sitk.ConstantPadImageFilter()
    filt.SetConstant (0)
    filt.SetPadLowerBound ([1, 1, 1])
    filt.SetPadUpperBound ([1, 1, 1])
    binary_image = filt.Execute(binary_mask)

    # Create a VTK image
    binary_array = sitk.GetArrayFromImage(binary_image)
    vtkimg = sitk2vtk(binary_image, centre=True)

    # binary_array = sitk.GetArrayFromImage(binary_image)
    min_val = binary_array.min()
    max_val = binary_array.max()

    threshold = min_val + 0.5 * (max_val - min_val)

    vtkmesh = extractSurface(vtkimg, threshold)
    del vtkimg

    writeSTL(vtkmesh, stl_rel_path)
    del vtkmesh


    # Get HU/mu

    if ShouldGenerateNew(fname_HU, fname_mu):
```

```
        kernel_radius = 2;

        # Sheets are too slim to be eroded so much
        if (structure_name.find("sheet") != -1):
            kernel_radius = 1;

        # Erode the mask
        erode = sitk.BinaryErodeImageFilter();
        erode.SetKernelRadius(kernel_radius);
        erode.SetForegroundValue(1);
        sitk_eroded_mask = erode.Execute(binary_mask);
        del erode

        eroded_mask = np.array(sitk.GetArrayFromImage(sitk_eroded_mask));
        del sitk_eroded_mask

        # Apply mask to simulated CT
        erored_test = (eroded_mask == 1)

        test = phantom_array == structure_isovalue
        avg_HU = np.mean(real_CT_in_HU[erored_test])
        avg_mu = np.mean(real_CT_in_mu[erored_test])

        # print("\t\t\"Material\": [\"HU\",", avg_HU, "]")

        ref_data[structure_name] = [avg_HU, avg_mu]
        digital_phatom_in_HU[test] = round(avg_HU)
        digital_phatom_in_mu[test] = avg_mu
```

```
Process bronchioles
Process bronchus
Process trachea
Process diaphram
Process skin
Process heart
Process ribs_spine
Process scapulas
Process sternum
Process clavicle
Process sheets_low
Process sheets_med
Process sheets_high
Process tumours_630HU
Process tumours_100HU
```

[21]:
```
if ShouldGenerateNew(fname_HU, fname_mu):

    if SAVE_DATA:
        sitk_digital_phatom_in_HU = sitk.GetImageFromArray(digital_phatom_in_HU)

        sitk_digital_phatom_in_HU.SetOrigin((-pixel_width * digital_phatom_in_HU.
↪shape[2] / 2.0,
                        -pixel_width * digital_phatom_in_HU.shape[1] / 2.0,
                        -pixel_height * digital_phatom_in_HU.shape[0] / 2.0))

        sitk_digital_phatom_in_HU.SetSpacing([pixel_width, pixel_width,␣
↪pixel_height])
        sitk.WriteImage(sitk_digital_phatom_in_HU, fname_HU, useCompression=True)



        sitk_digital_phatom_in_mu = sitk.GetImageFromArray(digital_phatom_in_mu)

        sitk_digital_phatom_in_mu.SetOrigin((-pixel_width * digital_phatom_in_mu.
↪shape[2] / 2.0,
                       -pixel_width * digital_phatom_in_mu.shape[1] / 2.0,
                        -pixel_height * digital_phatom_in_mu.shape[0] / 2.0))

        sitk_digital_phatom_in_mu.SetSpacing([pixel_width, pixel_width,␣
↪pixel_height])
        sitk.WriteImage(sitk_digital_phatom_in_mu, fname_mu, useCompression=True)
```

6.1 Create a phantom model from each mesh and its material

[22]:
```
json2gvxr.initSamples();
```

```
lungman_data/meshes/bronchioles.stl     nb_faces:       5338192 nb_vertices:
16014576        bounding_box (in cm):   (-12.625, -8.3125, -13.65)
(11.8125, 7.3125, 12.81)
lungman_data/meshes/bronchus.stl        nb_faces:       701200  nb_vertices:
2103600 bounding_box (in cm):   (-11.375, -8.0625, -11.97)      (11.75, 6.5,
10.57)
lungman_data/meshes/trachea.stl nb_faces:       88328   nb_vertices:    264984
bounding_box (in cm):   (-2.8125, -6.625, -1.68)        (3.8125, 0.5, 14.84)
lungman_data/meshes/diaphram.stl        nb_faces:       507436  nb_vertices:
1522308 bounding_box (in cm):   (-12.625, -9, -14.84)   (11.875, 6.3125, -8.26)
lungman_data/meshes/skin.stl    nb_faces:       6416748 nb_vertices:    19250244
bounding_box (in cm):   (-15.9375, -11.75, -14.84)      (15.9375, 10.75, 14.84)
lungman_data/meshes/heart.stl   nb_faces:       440588  nb_vertices:    1321764
bounding_box (in cm):   (-2.6875, -8.375, -10.71)       (9.5625, 3.4375, 8.82)
lungman_data/meshes/ribs_spine.stl      nb_faces:       2225360 nb_vertices:
```

```
6676080 bounding_box (in cm):   (-14.5, -10.125, -14.84)        (13.625, 9.125,
14.84)
lungman_data/meshes/scapulas.stl        nb_faces:       568148  nb_vertices:
1704444 bounding_box (in cm):   (-15.9375, -3.8125, -2.8)       (15.9375,
8.1875, 14.84)
lungman_data/meshes/sternum.stl nb_faces:       101856  nb_vertices:    305568
bounding_box (in cm):   (-3.75, -9.5, -5.53)    (2.6875, -4.4375, 9.1)
lungman_data/meshes/clavicle.stl        nb_faces:       131804  nb_vertices:
395412  bounding_box (in cm):   (-12.375, -6.5625, 8.47)        (12.375, 4.0625,
14.84)
lungman_data/meshes/sheets_low.stl      nb_faces:       1160784 nb_vertices:
3482352 bounding_box (in cm):   (-15.9375, 6.1875, -14.84)      (15.9375,
11.1875, 14.84)
lungman_data/meshes/sheets_med.stl      nb_faces:       1120640 nb_vertices:
3361920 bounding_box (in cm):   (-15.9375, 9.4375, -14.84)      (15.9375, 14,
14.84)
lungman_data/meshes/sheets_high.stl     nb_faces:       467752  nb_vertices:
1403256 bounding_box (in cm):   (-15.9375, 13.3125, -14.84)     (15.9375,
15.9375, 14.84)
lungman_data/meshes/tumours_630HU.stl   nb_faces:       4952    nb_vertices:
14856   bounding_box (in cm):   (-10.625, -3.3125, -8.68)       (5.375, 2.375,
5.81)
lungman_data/meshes/tumours_100HU.stl   nb_faces:       3968    nb_vertices:
11904   bounding_box (in cm):   (-4.625, -4.75, -8.54)  (11.75, 2.9375, -0.14)
```

[23]:
```
number_of_triangles = 0

for sample in json2gvxr.params["Samples"]:
    label = sample["Label"]
    number_of_triangles_in_mesh = gvxr.getNumberOfPrimitives(label)
    number_of_triangles += number_of_triangles_in_mesh

print("There are", f"{number_of_triangles:,}", "triangles in total")
```

```
There are 19,277,756 triangles in total
```

6.2 Visualise the virtual patient

[24]:
```
if (DO_K3D_PLOT):
    plot = k3d.plot()
    plot.background_color = 0xffffff

    for sample in json2gvxr.params["Samples"]:

        label = sample["Label"]
```

```
        fname = sample["Path"]

         #r, g, b, a = gvxr.getAmbientColour(label)
         #R = math.floor(255*r)
         #G = math.floor(255*g)
         #B = math.floor(255*b)
         #A = math.floor(255*a)
        R = sample["Colour"][0];
        G = sample["Colour"][1];
        B = sample["Colour"][2];
        o = sample["Colour"][3];

        k3d_color = 0;
        k3d_color |= (R & 255) << 16;
        k3d_color |= (G & 255) << 8;
        k3d_color |= (B & 255);

        mesh_from_stl_file = mesh.Mesh.from_file(fname)
        opacity = o;
         #if label == "Skin":
         #    opacity = 0.2
         #else:
         #    opacity = 1
        geometry = k3d.mesh(mesh_from_stl_file.vectors.flatten(),
                            range(int(mesh_from_stl_file.vectors.flatten().
↪shape[0] / 3)),
                            color=k3d_color,
                            wireframe=False,
                            flat_shading=False,
                            name=fname,
                            opacity=opacity)

        plot += geometry

    plot.display()
    plot.camera = [458.4242199518181, -394.5268107574361, 59.58430140683608, 93.
↪26420522817403, -15.742963565665017, -45.88423611599179, -0.08892603121323975,␣
↪0.11140808541436767, 0.9897880578573034]
```

Output()

[25]:
```
fname = 'plots/lungman_model.png'
if DO_K3D_PLOT and ShouldGenerateNew(fname):


    plot.fetch_screenshot() # Not sure why, but we need to do it twice to get␣
↪the right screenshot
```

```
    data = base64.b64decode(plot.screenshot)
    with open(fname,'wb') as fp:
        fp.write(data)
        fp.flush();
        fp.close();
```

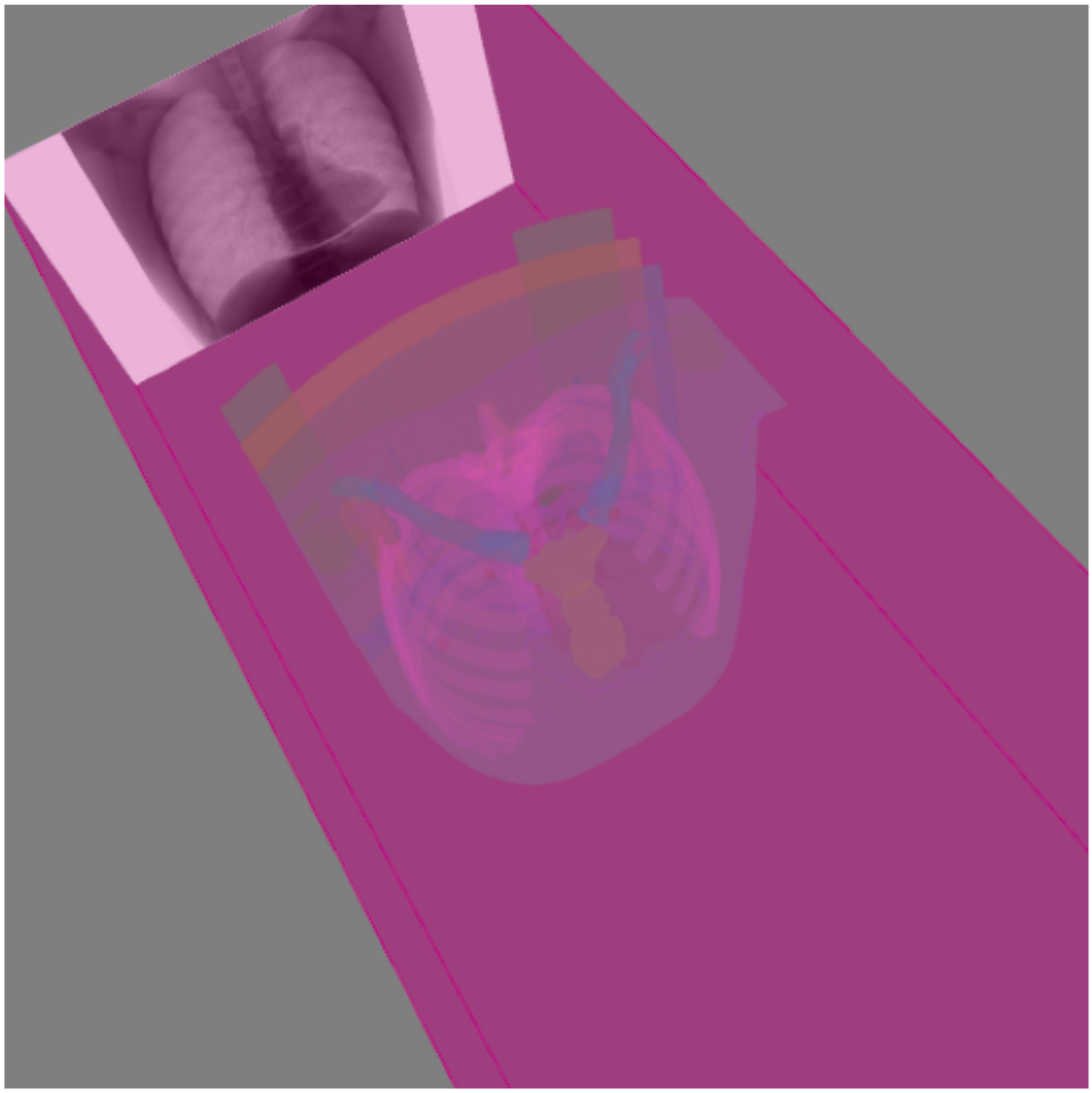
6.3 Visualise a single projection

[26]:
```
gvxr.computeXRayImage()
gvxr.displayScene()

# Give each mesh an alpha value
alpha = 0.2;
for i in range(gvxr.getNumberOfChildren('root')):
    label = gvxr.getChildLabel('root', i);
    pRGBA = gvxr.getAmbientColour(label);
    gvxr.setColour(label, pRGBA[0], pRGBA[1], pRGBA[2],alpha);

gvxr.useLighing(False)
gvxr.useWireframe(False)
gvxr.setZoom(1000)
gvxr.setSceneRotationMatrix([ 0.8535534,  0.5000000, -0.1464466,0,
  -0.5000000,  0.7071068, -0.5000000,0,
  -0.1464466,  0.5000000,  0.8535534,0,
                           0.0, 0.0, 0.0, 1.0])
gvxr.displayScene()


screenshot = gvxr.takeScreenshot()

plt.figure(figsize= (10,10))
plt.title("Screenshot")
plt.imshow(screenshot)
plt.axis('off')
```

```
Thu Mar 24 21:14:57 2022 ---- file_name:        Thu Mar 24 21:14:57 2022 ----
file_name:        Thu Mar 24 21:14:57 2022 ---- file_name:        Thu Mar 24
21:14:58 2022 ---- file_name:        Thu Mar 24 21:15:01 2022 ---- file_name:
Thu Mar 24 21:15:01 2022 ---- file_name:        Thu Mar 24 21:15:02 2022 ----
file_name:        Thu Mar 24 21:15:02 2022 ---- file_name:        Thu Mar 24
21:15:02 2022 ---- file_name:        Thu Mar 24 21:15:02 2022 ---- file_name:
Thu Mar 24 21:15:03 2022 ---- file_name:        Thu Mar 24 21:15:04 2022 ----
file_name:        Thu Mar 24 21:15:04 2022 ---- file_name:        Thu Mar 24
21:15:04 2022 ---- file_name:        Thu Mar 24 21:15:04 2022 ---- file_name:
0 0 500 500
0 0 512 512
```

[26]: (-0.5, 511.5, 511.5, -0.5)

Screenshot



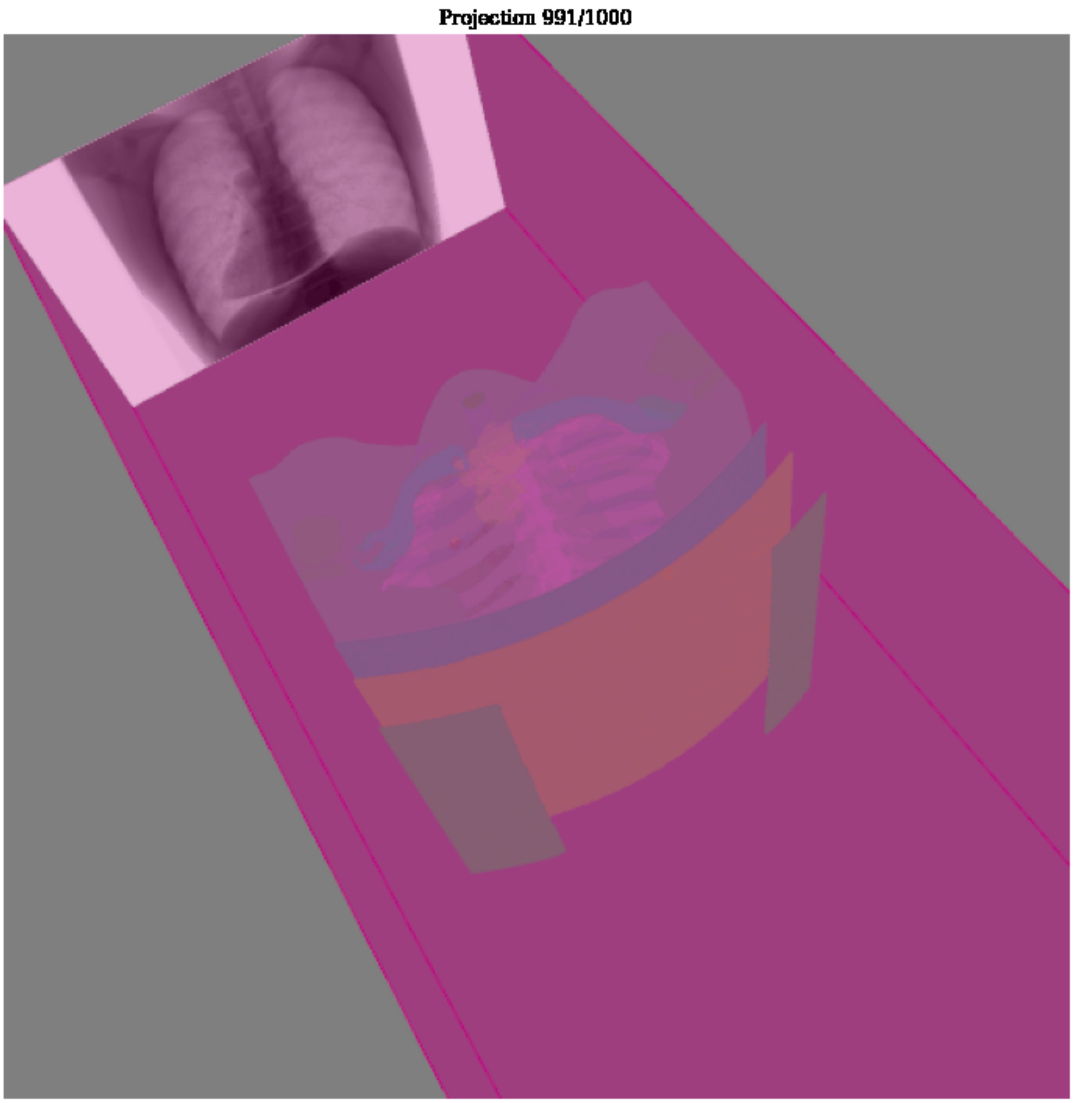
[27]:
```
%%capture
runtimes = []
fname = "gVirtualXRay_output_data/lungman_flat.mha"
if ShouldGenerateNew(fname):


    gvxr.disableArtefactFiltering()

    if DO_ARTEFACT_FILTERING_ON_GPU:
        gvxr.enableArtefactFilteringOnGPU()
```

```
elif DO_ARTEFACT_FILTERING_ON_CPU:
    gvxr.enableArtefactFilteringOnCPU()

raw_projections = [];
angles = [];
runtimes = []

# Create a GIF file
writer = None
fname_gif = "plots/lungman_acquisition.gif"

if not os.path.exists(fname_gif):
    writer = imageio.get_writer(fname_gif, mode='I')

# Save the transformation matrix
transformation_matrix_backup = gvxr.getSceneTransformationMatrix()

rotation_axis = json2gvxr.params["Detector"]["UpVector"]

for angle_id in range(0, number_of_projections):

    # Add the rotation angle, starting from 0
    angles.append(angle_id * angular_step)

    # Compute an X-ray image
    # xray_image = np.array(gvxr.computeXRayImage());
    start_time = datetime.datetime.now()

    xray_image = gvxr.computeXRayImage()

    # if xray_image.shape != [208, 1062]:
    #     xray_image = resize(xray_image, [208, 1062])

    # xray_image = np.array(gvxr.computeXRayImage());

    end_time = datetime.datetime.now()
    delta_time = end_time - start_time
    runtimes.append(delta_time.total_seconds() * 1000)

    # Add to the set of projections
    raw_projections.append(xray_image)

    # Update the rendering
    gvxr.displayScene();

    # Take a screenshot
    if writer is not None:
```

```
            if not angle_id % 30:
                screenshot = gvxr.takeScreenshot()

                plt.figure(figsize= (10,10))
                plt.title("Projection " + str(angle_id + 1) + "/" +␣
↪str(number_of_projections))
                plt.imshow(screenshot)
                plt.axis('off')

                plt.tight_layout()

                plt.savefig('temp.png')
                plt.close()


                image = imageio.imread("temp.png")
                writer.append_data(image)

        # Rotate the sample
        gvxr.rotateScene(angular_step, rotation_axis[0], rotation_axis[1],␣
↪rotation_axis[2])

    # We're done with the writer
    if writer is not None:
        writer.close()
        os.remove("temp.png")

    # Convert to numpy arrays
    raw_projections = np.array(raw_projections)

    # Restore the transformation matrix
    gvxr.setSceneTransformationMatrix(transformation_matrix_backup)

    # Update the rendering
    gvxr.displayScene();
```

[28]:
```
if (len(runtimes) > 0):
    runtime_avg = round(np.mean(runtimes))
    runtime_std = round(np.std(runtimes))
else:
    runtime_avg = -1;
    runtime_std = 0;
```

[29]:
```
with open('./plots/lungman_acquisition.gif','rb') as f:
    display(Image(data=f.read(), format='png', width=500))
```



7 Correct flat-field

Taking advantage of the detector response when there is no sample can help improve the quality of images when a sample is present. To elaborate, any variance between pixels when the detector is dark (X-Ray beam off) or full (X-Ray beam on) with no density will affect the quality of images with a sample. Factoring for this systematic error is called flat-field correction.
N: corrected image
P: projection
D: dark field
F: full field
$N = \frac{P-D}{F-D}$

In this routine the projection data is flat-fielded.

[30]:
```
if ShouldGenerateNew(fname):

    corrected_projections = flatFieldCorrection(raw_projections)
    corrected_projections = np.array(corrected_projections).astype(np.single)

    if SAVE_DATA:
        sitk_image = sitk.GetImageFromArray(corrected_projections)
        sitk_image.SetSpacing([pixel_width, pixel_height, angular_step])
        sitk.WriteImage(sitk_image, fname, useCompression=True)
        del raw_projections # Not needed anymore

else:
    temp = sitk.ReadImage(fname)
    corrected_projections = sitk.GetArrayFromImage(temp)
```

8 Negative log normalisation

[31]:
```
fname = "gVirtualXRay_output_data/lungman_minus_log_projs.mha"

if ShouldGenerateNew(fname):

    minus_log_projs = minusLog(corrected_projections)

    if SAVE_DATA:
        sitk_image = sitk.GetImageFromArray(minus_log_projs)
        sitk_image.SetSpacing([pixel_width, pixel_height, angular_step])
        sitk.WriteImage(sitk_image, fname, useCompression=True)

else:
    temp = sitk.ReadImage(fname)
    minus_log_projs = sitk.GetArrayFromImage(temp)

del corrected_projections # Not needed anymore
```

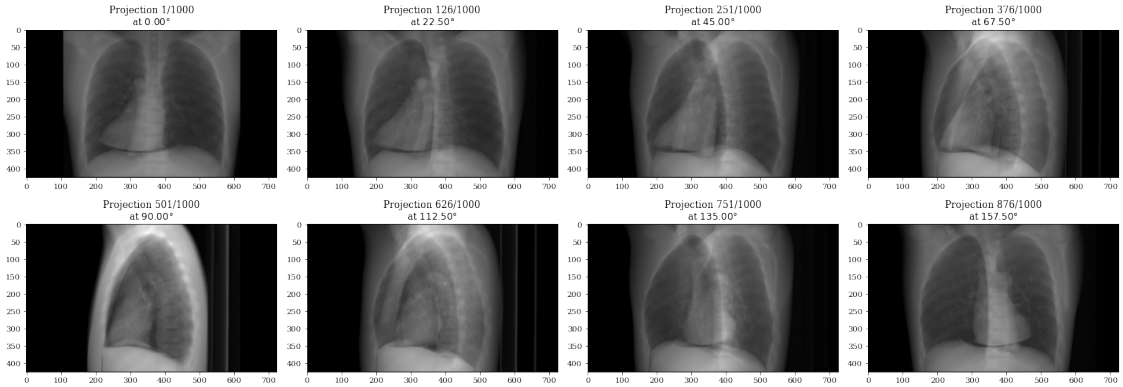
Display the images

[32]:
```
proj_min = minus_log_projs.min()
proj_max = minus_log_projs.max()
```

Draw the projection

[33]:
```
ncols = 4
nrows = 2
```

```
step = int(minus_log_projs.shape[0] / (ncols * nrows))
slices = range(0, int(minus_log_projs.shape[0]), step)

fig = plt.figure(figsize= (20, 7))

for i in range(ncols):
    for j in range(nrows):
        index = j * ncols + i

        slice_id = slices[index]

        ax = fig.add_subplot(nrows, ncols, index + 1)
        ax.set_title("Projection " + str(slice_id + 1) + "/" +␣
↪str(minus_log_projs.shape[0]) + "\nat $" + "{:.2f}".format(angles[slice_id]) +␣
↪"\degree$")
        ax.imshow(skimage.transform.rotate(minus_log_projs[slice_id], 180),
                  cmap='gray',
                  vmin=proj_min,
                  vmax=proj_max)

plt.tight_layout()


plt.savefig('plots/lungmand-simulated-projs.pdf')
plt.savefig('plots/lungmand-simulated-projs.png')
```



8.1 Optimise Plastimatch centre

Use objective function to find optimimum centre. i.e. register the DRR onto the radiograph

[34]:
```
from pymoo.util.misc import stack
from pymoo.core.problem import Problem
from pymoo.core.problem import ElementwiseProblem
from threading import Thread
from sklearn.metrics import mean_absolute_percentage_error

def normImage(image_to_normalise):
    image_to_normalise -= np.mean(image_to_normalise);
    stddev = np.std(image_to_normalise);
    if (stddev == 0): stddev = 0.0001;
    image_to_normalise/= stddev;

def measure(truth, predict):
    N = 1.0;
    dims = np.shape(truth);
    for i in range(0, len(dims)):
        N *= dims[i];
    if (N == 0): return -1, -1, -1, -1, -1;

    zncc_denom = N * np.std(truth) * np.std(predict);
    if (zncc_denom == 0): zncc_denom = 0.00001;

    sub = truth - predict;

    mae_score = np.sum(np.abs(sub)) / N;
    zncc_score =  np.sum( (truth  - np.mean(truth)) *(predict - np.
 ↪mean(predict))) / zncc_denom;
    rmse_score =  np.sqrt(np.sum(np.power(sub, 2)) / N)
    mape_score = mean_absolute_percentage_error(truth, predict);
    ssim_score = ssim(truth, predict);
    return mae_score, zncc_score, rmse_score, mape_score, ssim_score

def objective(cx, cy):
        DRR = doLungmanDRRNumpy(g_NRM[0], g_NRM[1], g_NRM[2],
                            cx, cy,
                             "DRR_",
                             g_XRay.shape[1], g_XRay.shape[0]

                            );
        DRR = DRR.astype(np.single);
        normImage(DRR);
        mae, zncc, rmse, mape, ssim = measure(g_XRay, DRR);
        zncc = 1.0 - ((zncc + 1.0) /2.0);
        ssim = 1.0 - ssim;
        row = []

        row.append(mae);
```

```
        row.append(zncc);
        row.append(rmse);
        row.append(mape);
        row.append(ssim);
        return row;

class MyProblem(Problem):

    def __init__(self):
        super().__init__(n_var=2,
                         n_obj=5,
                         n_constr=0,
                         xl=np.array([0, -g_XRay.shape[0]]),
                         xu=np.array([g_XRay.shape[1],0])
                         )




    def _evaluate(self, X, out, *args, **kwargs):
            objs = []
            for tuple in X:
                objs.append(objective(tuple[0], tuple[1]));

            out["F"] = objs;


import time
from pymoo.factory import get_termination
from pymoo.algorithms.moo.nsga2 import NSGA2
from pymoo.factory import get_sampling, get_crossover, get_mutation

termination = get_termination("n_gen", 100)


algorithm = NSGA2(
    pop_size=40,
    n_offsprings=10,
    sampling=get_sampling("real_random"),
    crossover=get_crossover("real_sbx", prob=0.9, eta=15),
    mutation=get_mutation("real_pm", eta=20),
    eliminate_duplicates=False
)
#normImage(xray_AP);
#normImage(xray_RL);

from pymoo.optimize import minimize
```

Generate optimise result if not done so already

[35]:
```
import pymoo.core.result;

fname_nsga_rl_X = "gVirtualXRay_output_data/R-L-res-nsga2-X.dat";
fname_nsga_rl_F = "gVirtualXRay_output_data/R-L-res-nsga2-F.dat";
fname_nsga_ap_X = "gVirtualXRay_output_data/A-P-res-nsga2-X.dat";
fname_nsga_ap_F = "gVirtualXRay_output_data/A-P-res-nsga2-F.dat";

r_l_res_exists = not ShouldGenerateNew(fname_nsga_rl_X, fname_nsga_rl_F);

a_p_res_exists = not ShouldGenerateNew(fname_nsga_ap_X, fname_nsga_ap_F);

res_ap = pymoo.core.result.Result();
res_rl = pymoo.core.result.Result();

minus_log_proj_rl = np.copy(np.flip(minus_log_projs[(number_of_projections) //␣
 ↪2]));
minus_log_proj_ap = np.copy(np.flip(minus_log_projs[len(minus_log_projs) - 1]));
normImage(minus_log_proj_rl);
normImage(minus_log_proj_ap);
s="Time taken {t} seconds.";

if (r_l_res_exists):
    print("Getting R-L result from file");
    res_rl.X = np.loadtxt(fname_nsga_rl_X)
    res_rl.F = np.loadtxt(fname_nsga_rl_F)
else:
    print("Optimising R-L");
    g_NRM = [1, 0, 0]
    g_XRay = minus_log_proj_rl;

    problem = MyProblem();

    t_start = time.time();
    res_rl = minimize(problem,
                algorithm,
                termination,
                seed=1,
                save_history=True,
                verbose=True)

    t_end = time.time();
    print(s.format(t=(t_end - t_start)));

    np.savetxt(fname_nsga_rl_X, res_rl.X)
    np.savetxt(fname_nsga_rl_F, res_rl.F)
```

```
if (a_p_res_exists):
    print("Getting A-P result from file");
    res_ap.X = np.loadtxt(fname_nsga_ap_X)
    res_ap.F = np.loadtxt(fname_nsga_ap_F)
else:
    print("Optimising A-P");
    g_NRM = [0, -1, 0]
    g_XRay = minus_log_proj_ap;

    problem = MyProblem();

    t_start = time.time();
    res_ap = minimize(problem,
                algorithm,
                termination,
                seed=1,
                save_history=True,
                verbose=True)

    t_end = time.time();
    print(s.format(t=(t_end - t_start)));

    np.savetxt(fname_nsga_ap_X, res_ap.X)
    np.savetxt(fname_nsga_ap_F, res_ap.F)
```

```
Optimising R-L
I/O time: 0.000769 sec
Total time: 0.0356121 secs
I/O time: 0.000764 sec
Total time: 0.00750613 secs
I/O time: 0.000836 sec
Total time: 0.016633 secs
I/O time: 0.000783 sec
Total time: 0.0187359 secs
I/O time: 0.001495 sec
Total time: 0.0383291 secs
I/O time: 0.000771 sec
Total time: 0.0339139 secs
I/O time: 0.000815 sec
Total time: 0.023629 secs
I/O time: 0.000773 sec
Total time: 0.0137701 secs
I/O time: 0.000766 sec
Total time: 0.0326319 secs
I/O time: 0.000795 sec
Total time: 0.0169141 secs
```

```
I/O time: 0.001255 sec
Total time: 0.046633 secs
I/O time: 0.000770 sec
Total time: 0.0291162 secs
I/O time: 0.001422 sec
Total time: 0.0499239 secs
I/O time: 0.000768 sec
Total time: 0.0104671 secs
I/O time: 0.000774 sec
Total time: 0.0223269 secs
I/O time: 0.000766 sec
Total time: 0.011972 secs
I/O time: 0.000868 sec
Total time: 0.047085 secs
I/O time: 0.000889 sec
Total time: 0.0334969 secs
I/O time: 0.000791 sec
Total time: 0.0474181 secs
I/O time: 0.000763 sec
Total time: 0.012219 secs
I/O time: 0.000769 sec
Total time: 0.045743 secs
I/O time: 0.000882 sec
Total time: 0.0268252 secs
I/O time: 0.000756 sec
Total time: 0.0144351 secs
I/O time: 0.000772 sec
Total time: 0.0302598 secs
I/O time: 0.000791 sec
Total time: 0.0194318 secs
I/O time: 0.001854 sec
Total time: 0.0116711 secs
I/O time: 0.000757 sec
Total time: 0.016464 secs
I/O time: 0.000786 sec
Total time: 0.0255129 secs
I/O time: 0.000777 sec
Total time: 0.0306368 secs
I/O time: 0.000766 sec
Total time: 0.0454381 secs
I/O time: 0.000764 sec
Total time: 0.013834 secs
I/O time: 0.000781 sec
Total time: 0.037606 secs
I/O time: 0.000761 sec
Total time: 0.010597 secs
I/O time: 0.000773 sec
Total time: 0.0461378 secs
```

```
I/O time: 0.000850 sec
Total time: 0.0485511 secs
I/O time: 0.000760 sec
Total time: 0.0343978 secs
I/O time: 0.000770 sec
Total time: 0.020185 secs
I/O time: 0.000821 sec
Total time: 0.0244608 secs
I/O time: 0.000776 sec
Total time: 0.0335009 secs
I/O time: 0.000804 sec
Total time: 0.0448439 secs
=====================================================
n_gen |  n_eval |  n_nds  |     eps      |  indicator
=====================================================
    1 |      40 |       4 |            - |            -
I/O time: 0.000772 sec
Total time: 0.02948 secs
I/O time: 0.000789 sec
Total time: 0.0329869 secs
I/O time: 0.000767 sec
Total time: 0.016861 secs
I/O time: 0.000769 sec
Total time: 0.0137968 secs
I/O time: 0.000791 sec
Total time: 0.046854 secs
I/O time: 0.000781 sec
Total time: 0.03231 secs
I/O time: 0.000769 sec
Total time: 0.0249639 secs
I/O time: 0.000773 sec
Total time: 0.00971794 secs
I/O time: 0.000883 sec
Total time: 0.0340271 secs
I/O time: 0.000762 sec
Total time: 0.00788498 secs
    2 |      50 |       6 |  0.056143158 |            f
I/O time: 0.001574 sec
Total time: 0.0478802 secs
I/O time: 0.005183 sec
Total time: 0.0155652 secs
I/O time: 0.000771 sec
Total time: 0.0159571 secs
I/O time: 0.000812 sec
Total time: 0.0171561 secs
I/O time: 0.000776 sec
Total time: 0.0334151 secs
I/O time: 0.000806 sec
```

```
Total time: 0.0425541 secs
I/O time: 0.000748 sec
Total time: 0.033222 secs
I/O time: 0.000740 sec
Total time: 0.014405 secs
I/O time: 0.000762 sec
Total time: 0.0198278 secs
I/O time: 0.000756 sec
Total time: 0.0131192 secs
    3 |      60 |       5 |  0.046750707 |        ideal
I/O time: 0.000784 sec
Total time: 0.0488851 secs
I/O time: 0.000764 sec
Total time: 0.0180502 secs
I/O time: 0.000764 sec
Total time: 0.0092721 secs
I/O time: 0.000756 sec
Total time: 0.0116231 secs
I/O time: 0.003454 sec
Total time: 0.036423 secs
I/O time: 0.000766 sec
Total time: 0.03268 secs
I/O time: 0.000753 sec
Total time: 0.032717 secs
I/O time: 0.000836 sec
Total time: 0.0323019 secs
I/O time: 0.000787 sec
Total time: 0.0362298 secs
I/O time: 0.000779 sec
Total time: 0.0481479 secs
    4 |      70 |       5 |  0.00000E+00 |            f
I/O time: 0.000767 sec
Total time: 0.0211811 secs
I/O time: 0.000853 sec
Total time: 0.013833 secs
I/O time: 0.000783 sec
Total time: 0.0482171 secs
I/O time: 0.000757 sec
Total time: 0.0127749 secs
I/O time: 0.000794 sec
Total time: 0.0316179 secs
I/O time: 0.000769 sec
Total time: 0.0306571 secs
I/O time: 0.001148 sec
Total time: 0.050895 secs
I/O time: 0.001706 sec
Total time: 0.0502839 secs
I/O time: 0.001265 sec
```

```
Total time: 0.0499778 secs
I/O time: 0.000749 sec
Total time: 0.0159969 secs
    5 |      80 |       6 |  0.036572931 |        ideal
I/O time: 0.000782 sec
Total time: 0.045187 secs
I/O time: 0.000760 sec
Total time: 0.0111139 secs
I/O time: 0.000745 sec
Total time: 0.0152109 secs
I/O time: 0.000789 sec
Total time: 0.032732 secs
I/O time: 0.000766 sec
Total time: 0.031033 secs
I/O time: 0.000783 sec
Total time: 0.015691 secs
I/O time: 0.000782 sec
Total time: 0.046947 secs
I/O time: 0.000758 sec
Total time: 0.0188718 secs
I/O time: 0.000774 sec
Total time: 0.0401859 secs
I/O time: 0.001733 sec
Total time: 0.046849 secs
    6 |      90 |       6 |  0.00000E+00 |            f
I/O time: 0.000742 sec
Total time: 0.017715 secs
I/O time: 0.000765 sec
Total time: 0.0493081 secs
I/O time: 0.000755 sec
Total time: 0.0148139 secs
I/O time: 0.000794 sec
Total time: 0.00844002 secs
I/O time: 0.000750 sec
Total time: 0.0119982 secs
I/O time: 0.000758 sec
Total time: 0.0124919 secs
I/O time: 0.001147 sec
Total time: 0.0488031 secs
I/O time: 0.000745 sec
Total time: 0.00988007 secs
I/O time: 0.000841 sec
Total time: 0.0473759 secs
I/O time: 0.000805 sec
Total time: 0.0484781 secs
    7 |     100 |       6 |  0.00000E+00 |            f
I/O time: 0.000760 sec
Total time: 0.019093 secs
```

```
I/O time: 0.001136 sec
Total time: 0.0495241 secs
I/O time: 0.000762 sec
Total time: 0.0288849 secs
I/O time: 0.001289 sec
Total time: 0.0468929 secs
I/O time: 0.000876 sec
Total time: 0.048389 secs
I/O time: 0.000761 sec
Total time: 0.0161161 secs
I/O time: 0.001336 sec
Total time: 0.0473409 secs
I/O time: 0.000904 sec
Total time: 0.0294139 secs
I/O time: 0.001115 sec
Total time: 0.0490952 secs
I/O time: 0.001176 sec
Total time: 0.049417 secs
    8 |     110 |       1 |  0.134337902 |        ideal
I/O time: 0.000767 sec
Total time: 0.0484729 secs
I/O time: 0.000763 sec
Total time: 0.0113981 secs
I/O time: 0.001486 sec
Total time: 0.0456278 secs
I/O time: 0.001253 sec
Total time: 0.0486751 secs
I/O time: 0.000906 sec
Total time: 0.0446892 secs
I/O time: 0.000761 sec
Total time: 0.0139441 secs
I/O time: 0.001201 sec
Total time: 0.0474789 secs
I/O time: 0.001258 sec
Total time: 0.0473001 secs
I/O time: 0.000744 sec
Total time: 0.0138361 secs
I/O time: 0.001219 sec
Total time: 0.0474269 secs
    9 |     120 |       1 |  0.00000E+00 |            f
I/O time: 0.000756 sec
Total time: 0.00987911 secs
I/O time: 0.001248 sec
Total time: 0.0474911 secs
I/O time: 0.000759 sec
Total time: 0.00952101 secs
I/O time: 0.000769 sec
Total time: 0.032335 secs
```

```
I/O time: 0.000886 sec
Total time: 0.0477879 secs
I/O time: 0.000764 sec
Total time: 0.0333998 secs
I/O time: 0.001764 sec
Total time: 0.0489309 secs
I/O time: 0.000794 sec
Total time: 0.032238 secs
I/O time: 0.000758 sec
Total time: 0.017761 secs
I/O time: 0.000875 sec
Total time: 0.048516 secs
   10 |     130 |       1 |  0.377560616 |        ideal
I/O time: 0.000908 sec
Total time: 0.046828 secs
I/O time: 0.000855 sec
Total time: 0.0487139 secs
I/O time: 0.000764 sec
Total time: 0.050102 secs
I/O time: 0.000873 sec
Total time: 0.0146952 secs
I/O time: 0.000766 sec
Total time: 0.0112259 secs
I/O time: 0.000804 sec
Total time: 0.0484161 secs
I/O time: 0.001256 sec
Total time: 0.047842 secs
I/O time: 0.000808 sec
Total time: 0.049155 secs
I/O time: 0.000744 sec
Total time: 0.011616 secs
I/O time: 0.000876 sec
Total time: 0.015852 secs
   11 |     140 |       2 |  1.000000000 |        ideal
I/O time: 0.000771 sec
Total time: 0.00868797 secs
I/O time: 0.000753 sec
Total time: 0.020653 secs
I/O time: 0.000754 sec
Total time: 0.00939512 secs
I/O time: 0.000781 sec
Total time: 0.0487969 secs
I/O time: 0.001260 sec
Total time: 0.047852 secs
I/O time: 0.000737 sec
Total time: 0.0123272 secs
I/O time: 0.000742 sec
Total time: 0.0342472 secs
```

```
I/O time: 0.001297 sec
Total time: 0.047848 secs
I/O time: 0.000817 sec
Total time: 0.0566709 secs
I/O time: 0.000801 sec
Total time: 0.0516441 secs
   12 |     150 |       3 |  0.343797928 |        ideal
I/O time: 0.001254 sec
Total time: 0.0465341 secs
I/O time: 0.000788 sec
Total time: 0.050848 secs
I/O time: 0.000790 sec
Total time: 0.0461879 secs
I/O time: 0.000999 sec
Total time: 0.033782 secs
I/O time: 0.000749 sec
Total time: 0.00956917 secs
I/O time: 0.001257 sec
Total time: 0.0480361 secs
I/O time: 0.000799 sec
Total time: 0.048759 secs
I/O time: 0.000886 sec
Total time: 0.050452 secs
I/O time: 0.000745 sec
Total time: 0.013999 secs
I/O time: 0.000744 sec
Total time: 0.00814009 secs
   13 |     160 |       3 |  0.00000E+00 |            f
I/O time: 0.000883 sec
Total time: 0.050837 secs
I/O time: 0.001461 sec
Total time: 0.0497401 secs
I/O time: 0.000758 sec
Total time: 0.014286 secs
I/O time: 0.000882 sec
Total time: 0.0493901 secs
I/O time: 0.001123 sec
Total time: 0.046643 secs
I/O time: 0.000747 sec
Total time: 0.00809693 secs
I/O time: 0.000893 sec
Total time: 0.0512021 secs
I/O time: 0.000835 sec
Total time: 0.048893 secs
I/O time: 0.001278 sec
Total time: 0.0480931 secs
I/O time: 0.001415 sec
Total time: 0.0501091 secs
```

```
   14 |     170 |       3 |  0.00000E+00 |            f
I/O time: 0.000771 sec
Total time: 0.048794 secs
I/O time: 0.000905 sec
Total time: 0.048574 secs
I/O time: 0.000787 sec
Total time: 0.048928 secs
I/O time: 0.000801 sec
Total time: 0.049402 secs
I/O time: 0.001255 sec
Total time: 0.0480139 secs
I/O time: 0.001293 sec
Total time: 0.0487571 secs
I/O time: 0.000887 sec
Total time: 0.048497 secs
I/O time: 0.000793 sec
Total time: 0.0508671 secs
I/O time: 0.001152 sec
Total time: 0.0452471 secs
I/O time: 0.000774 sec
Total time: 0.048373 secs
   15 |     180 |       1 |  0.520881757 |        ideal
I/O time: 0.000878 sec
Total time: 0.0479889 secs
I/O time: 0.000788 sec
Total time: 0.0498002 secs
I/O time: 0.000781 sec
Total time: 0.0498309 secs
I/O time: 0.000896 sec
Total time: 0.0478749 secs
I/O time: 0.000779 sec
Total time: 0.0469599 secs
I/O time: 0.001457 sec
Total time: 0.0505059 secs
I/O time: 0.001192 sec
Total time: 0.050431 secs
I/O time: 0.000749 sec
Total time: 0.00814605 secs
I/O time: 0.000794 sec
Total time: 0.0500729 secs
I/O time: 0.001248 sec
Total time: 0.0498879 secs
   16 |     190 |       1 |  0.00000E+00 |            f
I/O time: 0.001246 sec
Total time: 0.048949 secs
I/O time: 0.000769 sec
Total time: 0.051101 secs
I/O time: 0.001248 sec
```

```
Total time: 0.0483811 secs
I/O time: 0.000884 sec
Total time: 0.0492401 secs
I/O time: 0.000785 sec
Total time: 0.0478458 secs
I/O time: 0.000774 sec
Total time: 0.0490031 secs
I/O time: 0.001284 sec
Total time: 0.0500672 secs
I/O time: 0.001291 sec
Total time: 0.0503981 secs
I/O time: 0.000778 sec
Total time: 0.0494661 secs
I/O time: 0.000705 sec
Total time: 0.0486069 secs
   17 |     200 |       1 |  0.00000E+00 |            f
I/O time: 0.000785 sec
Total time: 0.0474401 secs
I/O time: 0.001267 sec
Total time: 0.048795 secs
I/O time: 0.000776 sec
Total time: 0.048867 secs
I/O time: 0.000784 sec
Total time: 0.0491412 secs
I/O time: 0.000893 sec
Total time: 0.04777 secs
I/O time: 0.001270 sec
Total time: 0.04809 secs
I/O time: 0.000820 sec
Total time: 0.0476351 secs
I/O time: 0.000907 sec
Total time: 0.0488951 secs
I/O time: 0.000861 sec
Total time: 0.04863 secs
I/O time: 0.001335 sec
Total time: 0.04896 secs
   18 |     210 |       1 |  0.00000E+00 |            f
I/O time: 0.000866 sec
Total time: 0.0513279 secs
I/O time: 0.000787 sec
Total time: 0.0490491 secs
I/O time: 0.001241 sec
Total time: 0.0482609 secs
I/O time: 0.000885 sec
Total time: 0.0480561 secs
I/O time: 0.000778 sec
Total time: 0.047703 secs
I/O time: 0.000786 sec
```

```
Total time: 0.045572 secs
I/O time: 0.001068 sec
Total time: 0.0494342 secs
I/O time: 0.000870 sec
Total time: 0.04919 secs
I/O time: 0.000887 sec
Total time: 0.0506418 secs
I/O time: 0.000792 sec
Total time: 0.0508821 secs
   19 |     220 |       1 |  0.00000E+00 |            f
I/O time: 0.000874 sec
Total time: 0.0526371 secs
I/O time: 0.000772 sec
Total time: 0.052773 secs
I/O time: 0.000763 sec
Total time: 0.058043 secs
I/O time: 0.000770 sec
Total time: 0.046762 secs
I/O time: 0.000912 sec
Total time: 0.0489361 secs
I/O time: 0.000870 sec
Total time: 0.049082 secs
I/O time: 0.000781 sec
Total time: 0.047822 secs
I/O time: 0.000777 sec
Total time: 0.0483081 secs
I/O time: 0.000772 sec
Total time: 0.0526319 secs
I/O time: 0.000838 sec
Total time: 0.0489318 secs
   20 |     230 |       1 |  0.00000E+00 |            f
I/O time: 0.000812 sec
Total time: 0.0478401 secs
I/O time: 0.001247 sec
Total time: 0.0493982 secs
I/O time: 0.001311 sec
Total time: 0.0483439 secs
I/O time: 0.000785 sec
Total time: 0.048712 secs
I/O time: 0.000796 sec
Total time: 0.0525939 secs
I/O time: 0.001288 sec
Total time: 0.0476019 secs
I/O time: 0.000790 sec
Total time: 0.047858 secs
I/O time: 0.000791 sec
Total time: 0.047231 secs
I/O time: 0.002091 sec
```

```
Total time: 0.0498221 secs
I/O time: 0.000903 sec
Total time: 0.051235 secs
   21 |     240 |       1 |  0.00000E+00 |            f
I/O time: 0.000864 sec
Total time: 0.060847 secs
I/O time: 0.000773 sec
Total time: 0.047231 secs
I/O time: 0.000883 sec
Total time: 0.0490398 secs
I/O time: 0.001292 sec
Total time: 0.049305 secs
I/O time: 0.000781 sec
Total time: 0.0466979 secs
I/O time: 0.000837 sec
Total time: 0.04845 secs
I/O time: 0.001256 sec
Total time: 0.0496271 secs
I/O time: 0.000862 sec
Total time: 0.047971 secs
I/O time: 0.000786 sec
Total time: 0.0487828 secs
I/O time: 0.001263 sec
Total time: 0.0489349 secs
   22 |     250 |       2 |  1.000000000 |        ideal
I/O time: 0.000788 sec
Total time: 0.048038 secs
I/O time: 0.001152 sec
Total time: 0.0491509 secs
I/O time: 0.001829 sec
Total time: 0.052496 secs
I/O time: 0.000788 sec
Total time: 0.046092 secs
I/O time: 0.001255 sec
Total time: 0.0491879 secs
I/O time: 0.001243 sec
Total time: 0.0477309 secs
I/O time: 0.000779 sec
Total time: 0.0466149 secs
I/O time: 0.000797 sec
Total time: 0.0479829 secs
I/O time: 0.000794 sec
Total time: 0.0489149 secs
I/O time: 0.000779 sec
Total time: 0.04933 secs
   23 |     260 |       2 |  0.00000E+00 |            f
I/O time: 0.000872 sec
Total time: 0.0489421 secs
```

```
I/O time: 0.000775 sec
Total time: 0.0491991 secs
I/O time: 0.001501 sec
Total time: 0.048466 secs
I/O time: 0.000777 sec
Total time: 0.049489 secs
I/O time: 0.001818 sec
Total time: 0.0496759 secs
I/O time: 0.000891 sec
Total time: 0.0491731 secs
I/O time: 0.001372 sec
Total time: 0.0490971 secs
I/O time: 0.000885 sec
Total time: 0.0494189 secs
I/O time: 0.000780 sec
Total time: 0.048233 secs
I/O time: 0.000786 sec
Total time: 0.0485079 secs
   24 |     270 |       3 |  0.955803546 |        ideal
I/O time: 0.000782 sec
Total time: 0.050549 secs
I/O time: 0.000896 sec
Total time: 0.0507331 secs
I/O time: 0.000758 sec
Total time: 0.0489819 secs
I/O time: 0.000788 sec
Total time: 0.048717 secs
I/O time: 0.000833 sec
Total time: 0.049706 secs
I/O time: 0.001360 sec
Total time: 0.048106 secs
I/O time: 0.000787 sec
Total time: 0.047436 secs
I/O time: 0.000855 sec
Total time: 0.048692 secs
I/O time: 0.000802 sec
Total time: 0.047929 secs
I/O time: 0.000863 sec
Total time: 0.048228 secs
   25 |     280 |       4 |  0.00000E+00 |            f
I/O time: 0.000791 sec
Total time: 0.050772 secs
I/O time: 0.000816 sec
Total time: 0.049176 secs
I/O time: 0.000792 sec
Total time: 0.0488751 secs
I/O time: 0.000876 sec
Total time: 0.0503922 secs
```

```
I/O time: 0.000773 sec
Total time: 0.0499699 secs
I/O time: 0.000788 sec
Total time: 0.0472109 secs
I/O time: 0.000895 sec
Total time: 0.0491641 secs
I/O time: 0.001234 sec
Total time: 0.0486441 secs
I/O time: 0.001259 sec
Total time: 0.0487411 secs
I/O time: 0.001027 sec
Total time: 0.0520539 secs
   26 |     290 |       4 |  0.00000E+00 |            f
I/O time: 0.000766 sec
Total time: 0.0504062 secs
I/O time: 0.000789 sec
Total time: 0.0484691 secs
I/O time: 0.000797 sec
Total time: 0.049974 secs
I/O time: 0.000780 sec
Total time: 0.0520751 secs
I/O time: 0.000881 sec
Total time: 0.049377 secs
I/O time: 0.000781 sec
Total time: 0.0486469 secs
I/O time: 0.000808 sec
Total time: 0.048157 secs
I/O time: 0.000795 sec
Total time: 0.047951 secs
I/O time: 0.000878 sec
Total time: 0.0485551 secs
I/O time: 0.001420 sec
Total time: 0.0480552 secs
   27 |     300 |       5 |  0.00000E+00 |            f
I/O time: 0.000789 sec
Total time: 0.0483632 secs
I/O time: 0.001150 sec
Total time: 0.048857 secs
I/O time: 0.000784 sec
Total time: 0.0471399 secs
I/O time: 0.000789 sec
Total time: 0.0474761 secs
I/O time: 0.000908 sec
Total time: 0.0491331 secs
I/O time: 0.000906 sec
Total time: 0.0479939 secs
I/O time: 0.000804 sec
Total time: 0.0477459 secs
```

```
I/O time: 0.000780 sec
Total time: 0.0480449 secs
I/O time: 0.001420 sec
Total time: 0.0476651 secs
I/O time: 0.000802 sec
Total time: 0.0486591 secs
   28 |     310 |       1 |  0.029197633 |        ideal
I/O time: 0.000808 sec
Total time: 0.0478611 secs
I/O time: 0.001848 sec
Total time: 0.0484021 secs
I/O time: 0.000990 sec
Total time: 0.0477159 secs
I/O time: 0.000897 sec
Total time: 0.049257 secs
I/O time: 0.000802 sec
Total time: 0.047462 secs
I/O time: 0.000792 sec
Total time: 0.0452011 secs
I/O time: 0.000937 sec
Total time: 0.050195 secs
I/O time: 0.000986 sec
Total time: 0.0486748 secs
I/O time: 0.000790 sec
Total time: 0.0482171 secs
I/O time: 0.001364 sec
Total time: 0.0491011 secs
   29 |     320 |       1 |  0.00000E+00 |            f
I/O time: 0.000875 sec
Total time: 0.0480521 secs
I/O time: 0.000781 sec
Total time: 0.045912 secs
I/O time: 0.000971 sec
Total time: 0.046737 secs
I/O time: 0.001245 sec
Total time: 0.048897 secs
I/O time: 0.000791 sec
Total time: 0.0474432 secs
I/O time: 0.000787 sec
Total time: 0.0477569 secs
I/O time: 0.000797 sec
Total time: 0.0490921 secs
I/O time: 0.000803 sec
Total time: 0.0476859 secs
I/O time: 0.000876 sec
Total time: 0.0488429 secs
I/O time: 0.000861 sec
Total time: 0.0495989 secs
```

```
   30 |     330 |       2 |  1.000000000 |        ideal
I/O time: 0.000778 sec
Total time: 0.0483 secs
I/O time: 0.000795 sec
Total time: 0.047704 secs
I/O time: 0.000778 sec
Total time: 0.0482578 secs
I/O time: 0.000785 sec
Total time: 0.049186 secs
I/O time: 0.001061 sec
Total time: 0.04774 secs
I/O time: 0.001465 sec
Total time: 0.0501301 secs
I/O time: 0.000906 sec
Total time: 0.048769 secs
I/O time: 0.000885 sec
Total time: 0.0498879 secs
I/O time: 0.000879 sec
Total time: 0.0480771 secs
I/O time: 0.000776 sec
Total time: 0.0507472 secs
   31 |     340 |       2 |  0.00000E+00 |            f
I/O time: 0.000786 sec
Total time: 0.0492759 secs
I/O time: 0.000890 sec
Total time: 0.0482972 secs
I/O time: 0.000779 sec
Total time: 0.049036 secs
I/O time: 0.000901 sec
Total time: 0.0492499 secs
I/O time: 0.000777 sec
Total time: 0.0517561 secs
I/O time: 0.000803 sec
Total time: 0.0473731 secs
I/O time: 0.000809 sec
Total time: 0.0474601 secs
I/O time: 0.000906 sec
Total time: 0.0530069 secs
I/O time: 0.000877 sec
Total time: 0.0486782 secs
I/O time: 0.000782 sec
Total time: 0.0468359 secs
   32 |     350 |       3 |  0.00000E+00 |            f
I/O time: 0.000782 sec
Total time: 0.0485539 secs
I/O time: 0.000802 sec
Total time: 0.048326 secs
I/O time: 0.000782 sec
```

```
Total time: 0.0490909 secs
I/O time: 0.001274 sec
Total time: 0.0486641 secs
I/O time: 0.001242 sec
Total time: 0.0484169 secs
I/O time: 0.001412 sec
Total time: 0.051163 secs
I/O time: 0.000811 sec
Total time: 0.0533819 secs
I/O time: 0.000806 sec
Total time: 0.048687 secs
I/O time: 0.001046 sec
Total time: 0.058928 secs
I/O time: 0.000801 sec
Total time: 0.0425031 secs
   33 |     360 |       3 |  0.00000E+00 |            f
I/O time: 0.000802 sec
Total time: 0.047852 secs
I/O time: 0.001105 sec
Total time: 0.049721 secs
I/O time: 0.000870 sec
Total time: 0.049958 secs
I/O time: 0.000784 sec
Total time: 0.0482721 secs
I/O time: 0.000785 sec
Total time: 0.0490961 secs
I/O time: 0.000863 sec
Total time: 0.0488329 secs
I/O time: 0.000780 sec
Total time: 0.0482001 secs
I/O time: 0.001639 sec
Total time: 0.0500329 secs
I/O time: 0.000820 sec
Total time: 0.047704 secs
I/O time: 0.000775 sec
Total time: 0.0488839 secs
   34 |     370 |       3 |  0.00000E+00 |            f
I/O time: 0.000782 sec
Total time: 0.0517378 secs
I/O time: 0.000812 sec
Total time: 0.0494812 secs
I/O time: 0.000782 sec
Total time: 0.0490441 secs
I/O time: 0.000783 sec
Total time: 0.0484149 secs
I/O time: 0.000919 sec
Total time: 0.0494139 secs
I/O time: 0.000781 sec
```

```
Total time: 0.0555739 secs
I/O time: 0.000834 sec
Total time: 0.0532479 secs
I/O time: 0.000791 sec
Total time: 0.048321 secs
I/O time: 0.000861 sec
Total time: 0.0555241 secs
I/O time: 0.001267 sec
Total time: 0.0495191 secs
   35 |     380 |       4 |  0.00000E+00 |            f
I/O time: 0.000820 sec
Total time: 0.051558 secs
I/O time: 0.001013 sec
Total time: 0.0452681 secs
I/O time: 0.000778 sec
Total time: 0.0485511 secs
I/O time: 0.000868 sec
Total time: 0.0490789 secs
I/O time: 0.000801 sec
Total time: 0.051832 secs
I/O time: 0.000770 sec
Total time: 0.0574429 secs
I/O time: 0.000792 sec
Total time: 0.0482469 secs
I/O time: 0.000777 sec
Total time: 0.0497088 secs
I/O time: 0.000794 sec
Total time: 0.04881 secs
I/O time: 0.000892 sec
Total time: 0.049058 secs
   36 |     390 |       4 |  0.00000E+00 |            f
I/O time: 0.000893 sec
Total time: 0.049463 secs
I/O time: 0.001211 sec
Total time: 0.04814 secs
I/O time: 0.000784 sec
Total time: 0.0477841 secs
I/O time: 0.000800 sec
Total time: 0.0497401 secs
I/O time: 0.000801 sec
Total time: 0.046937 secs
I/O time: 0.000916 sec
Total time: 0.050606 secs
I/O time: 0.000873 sec
Total time: 0.048214 secs
I/O time: 0.000791 sec
Total time: 0.047904 secs
I/O time: 0.000785 sec
```

```
Total time: 0.0481129 secs
I/O time: 0.000779 sec
Total time: 0.0480511 secs
   37 |     400 |       4 |  0.00000E+00 |            f
I/O time: 0.000828 sec
Total time: 0.049804 secs
I/O time: 0.000889 sec
Total time: 0.0481949 secs
I/O time: 0.000783 sec
Total time: 0.0477991 secs
I/O time: 0.001851 sec
Total time: 0.050792 secs
I/O time: 0.000783 sec
Total time: 0.0484378 secs
I/O time: 0.000775 sec
Total time: 0.0486221 secs
I/O time: 0.000840 sec
Total time: 0.0473301 secs
I/O time: 0.000899 sec
Total time: 0.0486059 secs
I/O time: 0.000899 sec
Total time: 0.0481861 secs
I/O time: 0.000791 sec
Total time: 0.0475419 secs
   38 |     410 |       4 |  0.00000E+00 |            f
I/O time: 0.000783 sec
Total time: 0.0480959 secs
I/O time: 0.000875 sec
Total time: 0.0495951 secs
I/O time: 0.000906 sec
Total time: 0.048209 secs
I/O time: 0.000792 sec
Total time: 0.0479259 secs
I/O time: 0.000793 sec
Total time: 0.0481832 secs
I/O time: 0.000791 sec
Total time: 0.0498149 secs
I/O time: 0.000794 sec
Total time: 0.0492098 secs
I/O time: 0.000817 sec
Total time: 0.048372 secs
I/O time: 0.000784 sec
Total time: 0.0484211 secs
I/O time: 0.001267 sec
Total time: 0.0472851 secs
   39 |     420 |       4 |  0.00000E+00 |            f
I/O time: 0.001053 sec
Total time: 0.0486369 secs
```

```
I/O time: 0.000759 sec
Total time: 0.048492 secs
I/O time: 0.000781 sec
Total time: 0.0484681 secs
I/O time: 0.000782 sec
Total time: 0.051096 secs
I/O time: 0.000851 sec
Total time: 0.0503199 secs
I/O time: 0.001205 sec
Total time: 0.050359 secs
I/O time: 0.000787 sec
Total time: 0.046598 secs
I/O time: 0.000898 sec
Total time: 0.0483179 secs
I/O time: 0.000897 sec
Total time: 0.0487669 secs
I/O time: 0.000854 sec
Total time: 0.0485239 secs
   40 |     430 |       4 |  0.00000E+00 |            f
I/O time: 0.000806 sec
Total time: 0.0489509 secs
I/O time: 0.000780 sec
Total time: 0.048414 secs
I/O time: 0.000777 sec
Total time: 0.0493369 secs
I/O time: 0.000809 sec
Total time: 0.0493648 secs
I/O time: 0.000795 sec
Total time: 0.0476758 secs
I/O time: 0.000810 sec
Total time: 0.047792 secs
I/O time: 0.000795 sec
Total time: 0.0520442 secs
I/O time: 0.000794 sec
Total time: 0.0492091 secs
I/O time: 0.000889 sec
Total time: 0.047616 secs
I/O time: 0.000790 sec
Total time: 0.048806 secs
   41 |     440 |       1 |  0.037893200 |        ideal
I/O time: 0.000805 sec
Total time: 0.048027 secs
I/O time: 0.001265 sec
Total time: 0.04915 secs
I/O time: 0.000791 sec
Total time: 0.0486538 secs
I/O time: 0.000780 sec
Total time: 0.0475111 secs
```

```
I/O time: 0.000804 sec
Total time: 0.054157 secs
I/O time: 0.000778 sec
Total time: 0.047595 secs
I/O time: 0.000761 sec
Total time: 0.0485971 secs
I/O time: 0.000927 sec
Total time: 0.0495529 secs
I/O time: 0.000910 sec
Total time: 0.048306 secs
I/O time: 0.001930 sec
Total time: 0.0506759 secs
   42 |     450 |       1 |  0.00000E+00 |            f
I/O time: 0.000833 sec
Total time: 0.047941 secs
I/O time: 0.000801 sec
Total time: 0.048831 secs
I/O time: 0.000796 sec
Total time: 0.047117 secs
I/O time: 0.000789 sec
Total time: 0.0481541 secs
I/O time: 0.000893 sec
Total time: 0.0482411 secs
I/O time: 0.000897 sec
Total time: 0.0490251 secs
I/O time: 0.000769 sec
Total time: 0.0532598 secs
I/O time: 0.000890 sec
Total time: 0.0480909 secs
I/O time: 0.000792 sec
Total time: 0.048965 secs
I/O time: 0.000894 sec
Total time: 0.049407 secs
   43 |     460 |       1 |  0.00000E+00 |            f
I/O time: 0.000777 sec
Total time: 0.049618 secs
I/O time: 0.001282 sec
Total time: 0.048686 secs
I/O time: 0.000801 sec
Total time: 0.0453939 secs
I/O time: 0.000904 sec
Total time: 0.0496919 secs
I/O time: 0.000876 sec
Total time: 0.0468328 secs
I/O time: 0.000894 sec
Total time: 0.048651 secs
I/O time: 0.000781 sec
Total time: 0.0501451 secs
```

```
I/O time: 0.000783 sec
Total time: 0.048214 secs
I/O time: 0.000766 sec
Total time: 0.0508339 secs
I/O time: 0.001333 sec
Total time: 0.0496221 secs
   44 |     470 |       1 |  0.00000E+00 |            f
I/O time: 0.000787 sec
Total time: 0.053082 secs
I/O time: 0.000781 sec
Total time: 0.049685 secs
I/O time: 0.000777 sec
Total time: 0.0495169 secs
I/O time: 0.001267 sec
Total time: 0.051146 secs
I/O time: 0.000775 sec
Total time: 0.0495491 secs
I/O time: 0.000888 sec
Total time: 0.049927 secs
I/O time: 0.000795 sec
Total time: 0.0486679 secs
I/O time: 0.000775 sec
Total time: 0.0498772 secs
I/O time: 0.000834 sec
Total time: 0.0495651 secs
I/O time: 0.001207 sec
Total time: 0.0484581 secs
   45 |     480 |       1 |  0.00000E+00 |            f
I/O time: 0.000778 sec
Total time: 0.0471501 secs
I/O time: 0.000838 sec
Total time: 0.0490069 secs
I/O time: 0.000768 sec
Total time: 0.049577 secs
I/O time: 0.000778 sec
Total time: 0.0528159 secs
I/O time: 0.000903 sec
Total time: 0.0508921 secs
I/O time: 0.001285 sec
Total time: 0.051621 secs
I/O time: 0.000789 sec
Total time: 0.0489922 secs
I/O time: 0.000899 sec
Total time: 0.0477891 secs
I/O time: 0.000846 sec
Total time: 0.048691 secs
I/O time: 0.000783 sec
Total time: 0.0509851 secs
```

```
   46 |     490 |       1 |  0.00000E+00 |            f
I/O time: 0.000776 sec
Total time: 0.04935 secs
I/O time: 0.000791 sec
Total time: 0.050142 secs
I/O time: 0.000848 sec
Total time: 0.0462821 secs
I/O time: 0.000796 sec
Total time: 0.052556 secs
I/O time: 0.001124 sec
Total time: 0.0488949 secs
I/O time: 0.000807 sec
Total time: 0.047807 secs
I/O time: 0.000784 sec
Total time: 0.0502038 secs
I/O time: 0.001438 sec
Total time: 0.051384 secs
I/O time: 0.000782 sec
Total time: 0.049504 secs
I/O time: 0.000855 sec
Total time: 0.0504129 secs
   47 |     500 |       1 |  0.00000E+00 |            f
I/O time: 0.000799 sec
Total time: 0.048974 secs
I/O time: 0.000820 sec
Total time: 0.0483022 secs
I/O time: 0.000839 sec
Total time: 0.0487611 secs
I/O time: 0.000779 sec
Total time: 0.053477 secs
I/O time: 0.000796 sec
Total time: 0.0476151 secs
I/O time: 0.000897 sec
Total time: 0.048955 secs
I/O time: 0.000796 sec
Total time: 0.0490811 secs
I/O time: 0.000790 sec
Total time: 0.0486789 secs
I/O time: 0.001099 sec
Total time: 0.0472569 secs
I/O time: 0.001192 sec
Total time: 0.0481398 secs
   48 |     510 |       1 |  0.00000E+00 |            f
I/O time: 0.000810 sec
Total time: 0.0480361 secs
I/O time: 0.000774 sec
Total time: 0.0501521 secs
I/O time: 0.000793 sec
```

```
Total time: 0.0459831 secs
I/O time: 0.000779 sec
Total time: 0.0499129 secs
I/O time: 0.000817 sec
Total time: 0.0495269 secs
I/O time: 0.000821 sec
Total time: 0.0485601 secs
I/O time: 0.000870 sec
Total time: 0.05268 secs
I/O time: 0.000863 sec
Total time: 0.048383 secs
I/O time: 0.000797 sec
Total time: 0.0496838 secs
I/O time: 0.000898 sec
Total time: 0.0483871 secs
   49 |     520 |       1 |  0.00000E+00 |            f
I/O time: 0.000803 sec
Total time: 0.04702 secs
I/O time: 0.000902 sec
Total time: 0.0497282 secs
I/O time: 0.000784 sec
Total time: 0.0483589 secs
I/O time: 0.000806 sec
Total time: 0.0478089 secs
I/O time: 0.000857 sec
Total time: 0.0485611 secs
I/O time: 0.000781 sec
Total time: 0.0494461 secs
I/O time: 0.000792 sec
Total time: 0.0484622 secs
I/O time: 0.000752 sec
Total time: 0.046129 secs
I/O time: 0.000775 sec
Total time: 0.049099 secs
I/O time: 0.000885 sec
Total time: 0.048131 secs
   50 |     530 |       1 |  0.00000E+00 |            f
I/O time: 0.000802 sec
Total time: 0.048799 secs
I/O time: 0.000883 sec
Total time: 0.0493901 secs
I/O time: 0.000824 sec
Total time: 0.048629 secs
I/O time: 0.000777 sec
Total time: 0.049547 secs
I/O time: 0.000787 sec
Total time: 0.049181 secs
I/O time: 0.000877 sec
```

```
Total time: 0.0508502 secs
I/O time: 0.000910 sec
Total time: 0.0494239 secs
I/O time: 0.000792 sec
Total time: 0.048259 secs
I/O time: 0.000774 sec
Total time: 0.046819 secs
I/O time: 0.000922 sec
Total time: 0.048286 secs
   51 |     540 |       1 |  0.00000E+00 |            f
I/O time: 0.001358 sec
Total time: 0.049597 secs
I/O time: 0.000879 sec
Total time: 0.0477939 secs
I/O time: 0.000870 sec
Total time: 0.0486951 secs
I/O time: 0.001248 sec
Total time: 0.0467489 secs
I/O time: 0.000781 sec
Total time: 0.0492792 secs
I/O time: 0.000914 sec
Total time: 0.04931 secs
I/O time: 0.000781 sec
Total time: 0.048727 secs
I/O time: 0.000783 sec
Total time: 0.048986 secs
I/O time: 0.000787 sec
Total time: 0.0538061 secs
I/O time: 0.001349 sec
Total time: 0.0475001 secs
   52 |     550 |       1 |  0.00000E+00 |            f
I/O time: 0.000791 sec
Total time: 0.049329 secs
I/O time: 0.000900 sec
Total time: 0.0491529 secs
I/O time: 0.001343 sec
Total time: 0.049443 secs
I/O time: 0.000783 sec
Total time: 0.048033 secs
I/O time: 0.001967 sec
Total time: 0.049371 secs
I/O time: 0.000853 sec
Total time: 0.0539351 secs
I/O time: 0.000765 sec
Total time: 0.0487411 secs
I/O time: 0.000789 sec
Total time: 0.0500479 secs
I/O time: 0.000896 sec
```

```
Total time: 0.0504379 secs
I/O time: 0.000836 sec
Total time: 0.049242 secs
   53 |     560 |       2 |  1.000000000 |        ideal
I/O time: 0.000790 sec
Total time: 0.0496111 secs
I/O time: 0.000837 sec
Total time: 0.0506132 secs
I/O time: 0.000782 sec
Total time: 0.0531409 secs
I/O time: 0.000791 sec
Total time: 0.047251 secs
I/O time: 0.001839 sec
Total time: 0.0486841 secs
I/O time: 0.000769 sec
Total time: 0.0497689 secs
I/O time: 0.000775 sec
Total time: 0.048574 secs
I/O time: 0.000779 sec
Total time: 0.0484619 secs
I/O time: 0.000890 sec
Total time: 0.0507309 secs
I/O time: 0.001269 sec
Total time: 0.048059 secs
   54 |     570 |       2 |  0.00000E+00 |            f
I/O time: 0.000887 sec
Total time: 0.0497849 secs
I/O time: 0.000782 sec
Total time: 0.0488341 secs
I/O time: 0.001383 sec
Total time: 0.0485458 secs
I/O time: 0.000801 sec
Total time: 0.048171 secs
I/O time: 0.000770 sec
Total time: 0.048665 secs
I/O time: 0.000920 sec
Total time: 0.049125 secs
I/O time: 0.000810 sec
Total time: 0.0480621 secs
I/O time: 0.000758 sec
Total time: 0.0548768 secs
I/O time: 0.000893 sec
Total time: 0.0495529 secs
I/O time: 0.000905 sec
Total time: 0.0495529 secs
   55 |     580 |       2 |  0.00000E+00 |            f
I/O time: 0.000880 sec
Total time: 0.0496721 secs
```

```
I/O time: 0.000764 sec
Total time: 0.048559 secs
I/O time: 0.000822 sec
Total time: 0.0493701 secs
I/O time: 0.001250 sec
Total time: 0.046766 secs
I/O time: 0.000905 sec
Total time: 0.0496471 secs
I/O time: 0.000790 sec
Total time: 0.0509779 secs
I/O time: 0.000786 sec
Total time: 0.0493078 secs
I/O time: 0.000722 sec
Total time: 0.050725 secs
I/O time: 0.000789 sec
Total time: 0.047559 secs
I/O time: 0.000792 sec
Total time: 0.0484149 secs
   56 |     590 |       3 |  0.00000E+00 |            f
I/O time: 0.000784 sec
Total time: 0.0472178 secs
I/O time: 0.001010 sec
Total time: 0.048795 secs
I/O time: 0.000889 sec
Total time: 0.050529 secs
I/O time: 0.000819 sec
Total time: 0.049154 secs
I/O time: 0.000902 sec
Total time: 0.0490842 secs
I/O time: 0.000779 sec
Total time: 0.045929 secs
I/O time: 0.000929 sec
Total time: 0.048717 secs
I/O time: 0.000829 sec
Total time: 0.0501921 secs
I/O time: 0.001506 sec
Total time: 0.0500839 secs
I/O time: 0.001198 sec
Total time: 0.0577402 secs
   57 |     600 |       3 |  0.00000E+00 |            f
I/O time: 0.000864 sec
Total time: 0.0506248 secs
I/O time: 0.001232 sec
Total time: 0.0491569 secs
I/O time: 0.000851 sec
Total time: 0.0475399 secs
I/O time: 0.000769 sec
Total time: 0.0470171 secs
```

```
I/O time: 0.000773 sec
Total time: 0.0478311 secs
I/O time: 0.000824 sec
Total time: 0.0493269 secs
I/O time: 0.000888 sec
Total time: 0.0500131 secs
I/O time: 0.000791 sec
Total time: 0.0492711 secs
I/O time: 0.000786 sec
Total time: 0.0495951 secs
I/O time: 0.000794 sec
Total time: 0.0482712 secs
   58 |     610 |       3 |  0.00000E+00 |            f
I/O time: 0.000763 sec
Total time: 0.047858 secs
I/O time: 0.004728 sec
Total time: 0.053411 secs
I/O time: 0.000759 sec
Total time: 0.049051 secs
I/O time: 0.000783 sec
Total time: 0.047704 secs
I/O time: 0.001146 sec
Total time: 0.050905 secs
I/O time: 0.000772 sec
Total time: 0.051249 secs
I/O time: 0.000769 sec
Total time: 0.0492649 secs
I/O time: 0.000780 sec
Total time: 0.0496821 secs
I/O time: 0.000783 sec
Total time: 0.0489588 secs
I/O time: 0.000779 sec
Total time: 0.0482881 secs
   59 |     620 |       3 |  0.00000E+00 |            f
I/O time: 0.000834 sec
Total time: 0.0487969 secs
I/O time: 0.000890 sec
Total time: 0.0490909 secs
I/O time: 0.000771 sec
Total time: 0.048979 secs
I/O time: 0.000779 sec
Total time: 0.0474832 secs
I/O time: 0.000771 sec
Total time: 0.0495341 secs
I/O time: 0.000891 sec
Total time: 0.0498509 secs
I/O time: 0.000831 sec
Total time: 0.048233 secs
```

```
I/O time: 0.000845 sec
Total time: 0.048327 secs
I/O time: 0.001124 sec
Total time: 0.049582 secs
I/O time: 0.000851 sec
Total time: 0.04931 secs
   60 |     630 |       3 |  0.00000E+00 |            f
I/O time: 0.001422 sec
Total time: 0.048291 secs
I/O time: 0.001335 sec
Total time: 0.0480731 secs
I/O time: 0.000807 sec
Total time: 0.0488691 secs
I/O time: 0.000773 sec
Total time: 0.0474389 secs
I/O time: 0.000913 sec
Total time: 0.0505948 secs
I/O time: 0.000789 sec
Total time: 0.050844 secs
I/O time: 0.000904 sec
Total time: 0.0494261 secs
I/O time: 0.000809 sec
Total time: 0.0502341 secs
I/O time: 0.000788 sec
Total time: 0.0485778 secs
I/O time: 0.000983 sec
Total time: 0.048352 secs
   61 |     640 |       3 |  0.00000E+00 |            f
I/O time: 0.000779 sec
Total time: 0.048116 secs
I/O time: 0.000885 sec
Total time: 0.049459 secs
I/O time: 0.000802 sec
Total time: 0.0495319 secs
I/O time: 0.000890 sec
Total time: 0.0488479 secs
I/O time: 0.000783 sec
Total time: 0.047143 secs
I/O time: 0.000778 sec
Total time: 0.048754 secs
I/O time: 0.000777 sec
Total time: 0.0489261 secs
I/O time: 0.000803 sec
Total time: 0.045011 secs
I/O time: 0.000775 sec
Total time: 0.0493379 secs
I/O time: 0.000788 sec
Total time: 0.0502999 secs
```

```
   62 |     650 |       3 |  0.00000E+00 |            f
I/O time: 0.000822 sec
Total time: 0.0494819 secs
I/O time: 0.000784 sec
Total time: 0.0500979 secs
I/O time: 0.000770 sec
Total time: 0.046427 secs
I/O time: 0.000855 sec
Total time: 0.05006 secs
I/O time: 0.000816 sec
Total time: 0.047411 secs
I/O time: 0.000778 sec
Total time: 0.0514302 secs
I/O time: 0.000785 sec
Total time: 0.0454159 secs
I/O time: 0.000777 sec
Total time: 0.049608 secs
I/O time: 0.001290 sec
Total time: 0.0476201 secs
I/O time: 0.000794 sec
Total time: 0.051039 secs
   63 |     660 |       3 |  0.957214300 |        ideal
I/O time: 0.000772 sec
Total time: 0.0494239 secs
I/O time: 0.001272 sec
Total time: 0.05073 secs
I/O time: 0.000779 sec
Total time: 0.049221 secs
I/O time: 0.000797 sec
Total time: 0.0482929 secs
I/O time: 0.000866 sec
Total time: 0.0500062 secs
I/O time: 0.001248 sec
Total time: 0.0488839 secs
I/O time: 0.000759 sec
Total time: 0.0524571 secs
I/O time: 0.000773 sec
Total time: 0.051352 secs
I/O time: 0.000774 sec
Total time: 0.0493069 secs
I/O time: 0.000790 sec
Total time: 0.0480771 secs
   64 |     670 |       4 |  0.537409645 |        ideal
I/O time: 0.000777 sec
Total time: 0.049262 secs
I/O time: 0.000773 sec
Total time: 0.0495639 secs
I/O time: 0.000850 sec
```

```
Total time: 0.050333 secs
I/O time: 0.000894 sec
Total time: 0.0561881 secs
I/O time: 0.000775 sec
Total time: 0.0507238 secs
I/O time: 0.000787 sec
Total time: 0.0521801 secs
I/O time: 0.000791 sec
Total time: 0.04951 secs
I/O time: 0.000922 sec
Total time: 0.0501051 secs
I/O time: 0.000903 sec
Total time: 0.0487518 secs
I/O time: 0.000793 sec
Total time: 0.0522771 secs
   65 |     680 |       4 |  0.00000E+00 |            f
I/O time: 0.000881 sec
Total time: 0.0488081 secs
I/O time: 0.000794 sec
Total time: 0.0486259 secs
I/O time: 0.000776 sec
Total time: 0.0512431 secs
I/O time: 0.000801 sec
Total time: 0.050524 secs
I/O time: 0.000772 sec
Total time: 0.0464709 secs
I/O time: 0.000784 sec
Total time: 0.0471411 secs
I/O time: 0.000782 sec
Total time: 0.0485172 secs
I/O time: 0.000902 sec
Total time: 0.048084 secs
I/O time: 0.000791 sec
Total time: 0.0484569 secs
I/O time: 0.000880 sec
Total time: 0.0491679 secs
   66 |     690 |       5 |  0.281983745 |        ideal
I/O time: 0.000778 sec
Total time: 0.0466199 secs
I/O time: 0.000696 sec
Total time: 0.0511601 secs
I/O time: 0.000789 sec
Total time: 0.049546 secs
I/O time: 0.000808 sec
Total time: 0.0599039 secs
I/O time: 0.000781 sec
Total time: 0.0506589 secs
I/O time: 0.000780 sec
```

```
Total time: 0.053925 secs
I/O time: 0.000803 sec
Total time: 0.0466001 secs
I/O time: 0.000859 sec
Total time: 0.049304 secs
I/O time: 0.000803 sec
Total time: 0.0484629 secs
I/O time: 0.001244 sec
Total time: 0.048234 secs
   67 |     700 |       5 |  0.00000E+00 |            f
I/O time: 0.000759 sec
Total time: 0.047178 secs
I/O time: 0.000894 sec
Total time: 0.0493932 secs
I/O time: 0.000779 sec
Total time: 0.0463989 secs
I/O time: 0.000814 sec
Total time: 0.0488641 secs
I/O time: 0.000875 sec
Total time: 0.0476091 secs
I/O time: 0.000791 sec
Total time: 0.0491681 secs
I/O time: 0.001194 sec
Total time: 0.0489318 secs
I/O time: 0.000911 sec
Total time: 0.0510192 secs
I/O time: 0.000773 sec
Total time: 0.0505462 secs
I/O time: 0.000774 sec
Total time: 0.0481589 secs
   68 |     710 |       8 |  0.107662571 |            f
I/O time: 0.000791 sec
Total time: 0.0501599 secs
I/O time: 0.001254 sec
Total time: 0.0487108 secs
I/O time: 0.000790 sec
Total time: 0.049166 secs
I/O time: 0.000786 sec
Total time: 0.048104 secs
I/O time: 0.000792 sec
Total time: 0.0475368 secs
I/O time: 0.000764 sec
Total time: 0.055701 secs
I/O time: 0.000786 sec
Total time: 0.0480289 secs
I/O time: 0.000807 sec
Total time: 0.0477321 secs
I/O time: 0.000888 sec
```

```
Total time: 0.0492561 secs
I/O time: 0.000778 sec
Total time: 0.0484669 secs
   69 |     720 |       8 |  0.00000E+00 |            f
I/O time: 0.000782 sec
Total time: 0.0497861 secs
I/O time: 0.000823 sec
Total time: 0.0484681 secs
I/O time: 0.000774 sec
Total time: 0.0494881 secs
I/O time: 0.000775 sec
Total time: 0.0477431 secs
I/O time: 0.000798 sec
Total time: 0.0466301 secs
I/O time: 0.000871 sec
Total time: 0.0557249 secs
I/O time: 0.000860 sec
Total time: 0.0483789 secs
I/O time: 0.000787 sec
Total time: 0.0476589 secs
I/O time: 0.000779 sec
Total time: 0.0477719 secs
I/O time: 0.000787 sec
Total time: 0.0503941 secs
   70 |     730 |       7 |  0.240606255 |        ideal
I/O time: 0.000797 sec
Total time: 0.047709 secs
I/O time: 0.000766 sec
Total time: 0.047539 secs
I/O time: 0.000801 sec
Total time: 0.048526 secs
I/O time: 0.001269 sec
Total time: 0.0491168 secs
I/O time: 0.000892 sec
Total time: 0.0475271 secs
I/O time: 0.001273 sec
Total time: 0.0498779 secs
I/O time: 0.000776 sec
Total time: 0.0479901 secs
I/O time: 0.000783 sec
Total time: 0.050076 secs
I/O time: 0.000914 sec
Total time: 0.0497801 secs
I/O time: 0.000784 sec
Total time: 0.0496171 secs
   71 |     740 |       8 |  0.003968255 |            f
I/O time: 0.000788 sec
Total time: 0.0485752 secs
```

```
I/O time: 0.000854 sec
Total time: 0.0493569 secs
I/O time: 0.001055 sec
Total time: 0.0508239 secs
I/O time: 0.000790 sec
Total time: 0.049824 secs
I/O time: 0.000769 sec
Total time: 0.047785 secs
I/O time: 0.000774 sec
Total time: 0.0475039 secs
I/O time: 0.000789 sec
Total time: 0.0487208 secs
I/O time: 0.000763 sec
Total time: 0.049159 secs
I/O time: 0.000779 sec
Total time: 0.048604 secs
I/O time: 0.000764 sec
Total time: 0.0488331 secs
   72 |     750 |      10 |  0.00000E+00 |            f
I/O time: 0.000882 sec
Total time: 0.049648 secs
I/O time: 0.000788 sec
Total time: 0.048058 secs
I/O time: 0.000797 sec
Total time: 0.0482121 secs
I/O time: 0.000870 sec
Total time: 0.0491009 secs
I/O time: 0.000780 sec
Total time: 0.048713 secs
I/O time: 0.000922 sec
Total time: 0.0490849 secs
I/O time: 0.001321 sec
Total time: 0.0496321 secs
I/O time: 0.000778 sec
Total time: 0.0472069 secs
I/O time: 0.000931 sec
Total time: 0.049304 secs
I/O time: 0.000785 sec
Total time: 0.0487301 secs
   73 |     760 |      11 |  0.00000E+00 |            f
I/O time: 0.001272 sec
Total time: 0.0488122 secs
I/O time: 0.000807 sec
Total time: 0.0464361 secs
I/O time: 0.000792 sec
Total time: 0.0462258 secs
I/O time: 0.000906 sec
Total time: 0.0484052 secs
```

```
I/O time: 0.000901 sec
Total time: 0.0501139 secs
I/O time: 0.000776 sec
Total time: 0.0479479 secs
I/O time: 0.000784 sec
Total time: 0.049516 secs
I/O time: 0.000856 sec
Total time: 0.0492511 secs
I/O time: 0.000802 sec
Total time: 0.0503609 secs
I/O time: 0.000776 sec
Total time: 0.0535328 secs
   74 |     770 |      11 |  0.00000E+00 |            f
I/O time: 0.000929 sec
Total time: 0.0492959 secs
I/O time: 0.000789 sec
Total time: 0.0481551 secs
I/O time: 0.000818 sec
Total time: 0.0489759 secs
I/O time: 0.000749 sec
Total time: 0.050442 secs
I/O time: 0.001265 sec
Total time: 0.0478439 secs
I/O time: 0.000867 sec
Total time: 0.05019 secs
I/O time: 0.000790 sec
Total time: 0.0474172 secs
I/O time: 0.000793 sec
Total time: 0.0500498 secs
I/O time: 0.000782 sec
Total time: 0.047513 secs
I/O time: 0.000768 sec
Total time: 0.049325 secs
   75 |     780 |       9 |  0.061184460 |        ideal
I/O time: 0.000816 sec
Total time: 0.0493951 secs
I/O time: 0.000879 sec
Total time: 0.0497999 secs
I/O time: 0.000782 sec
Total time: 0.046572 secs
I/O time: 0.001164 sec
Total time: 0.0512011 secs
I/O time: 0.000745 sec
Total time: 0.0504298 secs
I/O time: 0.000778 sec
Total time: 0.0500588 secs
I/O time: 0.000890 sec
Total time: 0.0492439 secs
```

```
I/O time: 0.000784 sec
Total time: 0.050813 secs
I/O time: 0.000888 sec
Total time: 0.0498171 secs
I/O time: 0.001395 sec
Total time: 0.054306 secs
   76 |     790 |       9 |  0.00000E+00 |            f
I/O time: 0.000891 sec
Total time: 0.049175 secs
I/O time: 0.000788 sec
Total time: 0.0471499 secs
I/O time: 0.000782 sec
Total time: 0.0492489 secs
I/O time: 0.001346 sec
Total time: 0.0485039 secs
I/O time: 0.000796 sec
Total time: 0.0521719 secs
I/O time: 0.000906 sec
Total time: 0.0506499 secs
I/O time: 0.000773 sec
Total time: 0.054224 secs
I/O time: 0.000788 sec
Total time: 0.0483382 secs
I/O time: 0.000806 sec
Total time: 0.049392 secs
I/O time: 0.001278 sec
Total time: 0.048821 secs
   77 |     800 |       9 |  0.00000E+00 |            f
I/O time: 0.000846 sec
Total time: 0.048975 secs
I/O time: 0.000779 sec
Total time: 0.0476182 secs
I/O time: 0.000808 sec
Total time: 0.0486641 secs
I/O time: 0.000789 sec
Total time: 0.0467191 secs
I/O time: 0.001762 sec
Total time: 0.0501568 secs
I/O time: 0.000751 sec
Total time: 0.0540271 secs
I/O time: 0.000775 sec
Total time: 0.0459819 secs
I/O time: 0.000967 sec
Total time: 0.051183 secs
I/O time: 0.000776 sec
Total time: 0.048806 secs
I/O time: 0.001273 sec
Total time: 0.0489662 secs
```

```
   78 |     810 |      10 |  0.104168100 |        ideal
I/O time: 0.000788 sec
Total time: 0.0474999 secs
I/O time: 0.001527 sec
Total time: 0.0491991 secs
I/O time: 0.000893 sec
Total time: 0.0490191 secs
I/O time: 0.000788 sec
Total time: 0.0475421 secs
I/O time: 0.000789 sec
Total time: 0.0500979 secs
I/O time: 0.000777 sec
Total time: 0.0574582 secs
I/O time: 0.000782 sec
Total time: 0.0505099 secs
I/O time: 0.000911 sec
Total time: 0.0494568 secs
I/O time: 0.000929 sec
Total time: 0.0498462 secs
I/O time: 0.000789 sec
Total time: 0.047545 secs
   79 |     820 |       7 |  0.094584071 |        ideal
I/O time: 0.000874 sec
Total time: 0.0496211 secs
I/O time: 0.000787 sec
Total time: 0.0538809 secs
I/O time: 0.000774 sec
Total time: 0.047864 secs
I/O time: 0.001462 sec
Total time: 0.0489409 secs
I/O time: 0.001233 sec
Total time: 0.0506289 secs
I/O time: 0.000788 sec
Total time: 0.0456431 secs
I/O time: 0.000780 sec
Total time: 0.0498509 secs
I/O time: 0.001120 sec
Total time: 0.0490029 secs
I/O time: 0.000781 sec
Total time: 0.047725 secs
I/O time: 0.000781 sec
Total time: 0.04672 secs
   80 |     830 |       7 |  0.040869393 |        ideal
I/O time: 0.000770 sec
Total time: 0.05007 secs
I/O time: 0.000905 sec
Total time: 0.0479949 secs
I/O time: 0.000912 sec
```

```
Total time: 0.0496061 secs
I/O time: 0.000841 sec
Total time: 0.0493629 secs
I/O time: 0.000774 sec
Total time: 0.0488629 secs
I/O time: 0.000875 sec
Total time: 0.048285 secs
I/O time: 0.000901 sec
Total time: 0.049741 secs
I/O time: 0.000897 sec
Total time: 0.0492239 secs
I/O time: 0.000904 sec
Total time: 0.051646 secs
I/O time: 0.000778 sec
Total time: 0.047236 secs
   81 |     840 |       8 |  0.00000E+00 |            f
I/O time: 0.001271 sec
Total time: 0.0505831 secs
I/O time: 0.000900 sec
Total time: 0.0483139 secs
I/O time: 0.000800 sec
Total time: 0.0503359 secs
I/O time: 0.000785 sec
Total time: 0.0484781 secs
I/O time: 0.000769 sec
Total time: 0.048419 secs
I/O time: 0.000784 sec
Total time: 0.048975 secs
I/O time: 0.001242 sec
Total time: 0.04985 secs
I/O time: 0.000829 sec
Total time: 0.049526 secs
I/O time: 0.000785 sec
Total time: 0.048007 secs
I/O time: 0.000900 sec
Total time: 0.049495 secs
   82 |     850 |       8 |  0.016682472 |        ideal
I/O time: 0.000782 sec
Total time: 0.0464411 secs
I/O time: 0.001069 sec
Total time: 0.0480011 secs
I/O time: 0.000741 sec
Total time: 0.0500271 secs
I/O time: 0.000786 sec
Total time: 0.049772 secs
I/O time: 0.000886 sec
Total time: 0.0495729 secs
I/O time: 0.000702 sec
```

```
Total time: 0.0494041 secs
I/O time: 0.000766 sec
Total time: 0.047276 secs
I/O time: 0.000887 sec
Total time: 0.0483489 secs
I/O time: 0.000891 sec
Total time: 0.0504432 secs
I/O time: 0.001496 sec
Total time: 0.049813 secs
   83 |     860 |       8 |  0.00000E+00 |            f
I/O time: 0.000778 sec
Total time: 0.046946 secs
I/O time: 0.000789 sec
Total time: 0.0478208 secs
I/O time: 0.000794 sec
Total time: 0.0524712 secs
I/O time: 0.000897 sec
Total time: 0.04917 secs
I/O time: 0.001873 sec
Total time: 0.0506458 secs
I/O time: 0.000781 sec
Total time: 0.0473299 secs
I/O time: 0.000784 sec
Total time: 0.0490069 secs
I/O time: 0.000776 sec
Total time: 0.0488808 secs
I/O time: 0.001096 sec
Total time: 0.0485151 secs
I/O time: 0.000778 sec
Total time: 0.04632 secs
   84 |     870 |       8 |  0.00000E+00 |            f
I/O time: 0.000847 sec
Total time: 0.0475099 secs
I/O time: 0.000787 sec
Total time: 0.048959 secs
I/O time: 0.000795 sec
Total time: 0.0467479 secs
I/O time: 0.001232 sec
Total time: 0.0470641 secs
I/O time: 0.000769 sec
Total time: 0.0465128 secs
I/O time: 0.000833 sec
Total time: 0.04984 secs
I/O time: 0.001206 sec
Total time: 0.0484819 secs
I/O time: 0.000769 sec
Total time: 0.0483401 secs
I/O time: 0.000885 sec
```

```
Total time: 0.0493331 secs
I/O time: 0.001265 sec
Total time: 0.0458591 secs
   85 |     880 |       8 |  0.00000E+00 |            f
I/O time: 0.000781 sec
Total time: 0.048388 secs
I/O time: 0.000910 sec
Total time: 0.0504811 secs
I/O time: 0.000842 sec
Total time: 0.0569549 secs
I/O time: 0.000794 sec
Total time: 0.049201 secs
I/O time: 0.000880 sec
Total time: 0.0480111 secs
I/O time: 0.000777 sec
Total time: 0.0477619 secs
I/O time: 0.000780 sec
Total time: 0.050065 secs
I/O time: 0.000811 sec
Total time: 0.050231 secs
I/O time: 0.001411 sec
Total time: 0.0500221 secs
I/O time: 0.000800 sec
Total time: 0.0477331 secs
   86 |     890 |       8 |  0.079907316 |        ideal
I/O time: 0.000782 sec
Total time: 0.0490451 secs
I/O time: 0.000839 sec
Total time: 0.0492411 secs
I/O time: 0.000902 sec
Total time: 0.0504608 secs
I/O time: 0.001257 sec
Total time: 0.0510511 secs
I/O time: 0.000861 sec
Total time: 0.052407 secs
I/O time: 0.000857 sec
Total time: 0.0491819 secs
I/O time: 0.000909 sec
Total time: 0.050344 secs
I/O time: 0.001174 sec
Total time: 0.048197 secs
I/O time: 0.000793 sec
Total time: 0.0488811 secs
I/O time: 0.000787 sec
Total time: 0.0467141 secs
   87 |     900 |       9 |  0.106923328 |        ideal
I/O time: 0.000871 sec
Total time: 0.0490999 secs
```

```
I/O time: 0.000783 sec
Total time: 0.0471251 secs
I/O time: 0.000831 sec
Total time: 0.0489991 secs
I/O time: 0.001048 sec
Total time: 0.049113 secs
I/O time: 0.001599 sec
Total time: 0.0474701 secs
I/O time: 0.000776 sec
Total time: 0.0486748 secs
I/O time: 0.000774 sec
Total time: 0.0497341 secs
I/O time: 0.000813 sec
Total time: 0.0494211 secs
I/O time: 0.000896 sec
Total time: 0.047442 secs
I/O time: 0.000786 sec
Total time: 0.048912 secs
   88 |     910 |      10 |  0.415750498 |        ideal
I/O time: 0.001613 sec
Total time: 0.0464411 secs
I/O time: 0.000792 sec
Total time: 0.048321 secs
I/O time: 0.000789 sec
Total time: 0.04916 secs
I/O time: 0.000782 sec
Total time: 0.047606 secs
I/O time: 0.001163 sec
Total time: 0.04895 secs
I/O time: 0.000769 sec
Total time: 0.049356 secs
I/O time: 0.001165 sec
Total time: 0.050596 secs
I/O time: 0.000905 sec
Total time: 0.048501 secs
I/O time: 0.001124 sec
Total time: 0.0498428 secs
I/O time: 0.000780 sec
Total time: 0.0488138 secs
   89 |     920 |      10 |  0.00000E+00 |            f
I/O time: 0.000789 sec
Total time: 0.0500011 secs
I/O time: 0.001231 sec
Total time: 0.0597041 secs
I/O time: 0.000782 sec
Total time: 0.0492921 secs
I/O time: 0.000843 sec
Total time: 0.0475061 secs
```

```
I/O time: 0.000825 sec
Total time: 0.0492439 secs
I/O time: 0.001095 sec
Total time: 0.0485561 secs
I/O time: 0.000781 sec
Total time: 0.0481 secs
I/O time: 0.000784 sec
Total time: 0.04615 secs
I/O time: 0.000771 sec
Total time: 0.049814 secs
I/O time: 0.000788 sec
Total time: 0.046746 secs
   90 |     930 |      10 |  0.00000E+00 |            f
I/O time: 0.000799 sec
Total time: 0.0477779 secs
I/O time: 0.000782 sec
Total time: 0.0531969 secs
I/O time: 0.000772 sec
Total time: 0.0502019 secs
I/O time: 0.000777 sec
Total time: 0.0484419 secs
I/O time: 0.000802 sec
Total time: 0.0541861 secs
I/O time: 0.000777 sec
Total time: 0.0488131 secs
I/O time: 0.000797 sec
Total time: 0.0487309 secs
I/O time: 0.000848 sec
Total time: 0.0507231 secs
I/O time: 0.000775 sec
Total time: 0.0482008 secs
I/O time: 0.000783 sec
Total time: 0.0457909 secs
   91 |     940 |      11 |  0.00000E+00 |            f
I/O time: 0.001340 sec
Total time: 0.0488079 secs
I/O time: 0.000913 sec
Total time: 0.0475891 secs
I/O time: 0.000791 sec
Total time: 0.0494409 secs
I/O time: 0.000786 sec
Total time: 0.048872 secs
I/O time: 0.000856 sec
Total time: 0.0493031 secs
I/O time: 0.000782 sec
Total time: 0.0496042 secs
I/O time: 0.000803 sec
Total time: 0.0478981 secs
```

```
I/O time: 0.000790 sec
Total time: 0.0489869 secs
I/O time: 0.000792 sec
Total time: 0.047235 secs
I/O time: 0.000800 sec
Total time: 0.0486219 secs
   92 |     950 |      12 |  0.018567064 |        nadir
I/O time: 0.000874 sec
Total time: 0.055145 secs
I/O time: 0.001354 sec
Total time: 0.0575609 secs
I/O time: 0.000774 sec
Total time: 0.049484 secs
I/O time: 0.000778 sec
Total time: 0.0504351 secs
I/O time: 0.000835 sec
Total time: 0.0541298 secs
I/O time: 0.000778 sec
Total time: 0.0502501 secs
I/O time: 0.000779 sec
Total time: 0.050307 secs
I/O time: 0.000786 sec
Total time: 0.0479338 secs
I/O time: 0.000804 sec
Total time: 0.0498021 secs
I/O time: 0.000861 sec
Total time: 0.0507631 secs
   93 |     960 |      12 |  0.00000E+00 |            f
I/O time: 0.000779 sec
Total time: 0.0512021 secs
I/O time: 0.000769 sec
Total time: 0.050113 secs
I/O time: 0.000800 sec
Total time: 0.048718 secs
I/O time: 0.000775 sec
Total time: 0.0476809 secs
I/O time: 0.000807 sec
Total time: 0.047843 secs
I/O time: 0.001102 sec
Total time: 0.049113 secs
I/O time: 0.000983 sec
Total time: 0.0497251 secs
I/O time: 0.000796 sec
Total time: 0.0481379 secs
I/O time: 0.000790 sec
Total time: 0.047199 secs
I/O time: 0.000873 sec
Total time: 0.0491419 secs
```

```
   94 |     970 |      14 |  0.000967457 |            f
I/O time: 0.000799 sec
Total time: 0.047266 secs
I/O time: 0.000915 sec
Total time: 0.0493469 secs
I/O time: 0.000791 sec
Total time: 0.048821 secs
I/O time: 0.001220 sec
Total time: 0.0489471 secs
I/O time: 0.000785 sec
Total time: 0.048496 secs
I/O time: 0.000888 sec
Total time: 0.0650659 secs
I/O time: 0.000979 sec
Total time: 0.049191 secs
I/O time: 0.000910 sec
Total time: 0.049216 secs
I/O time: 0.000857 sec
Total time: 0.0502589 secs
I/O time: 0.004951 sec
Total time: 0.0541821 secs
   95 |     980 |      14 |  0.040378525 |        ideal
I/O time: 0.000814 sec
Total time: 0.0495791 secs
I/O time: 0.000784 sec
Total time: 0.0475571 secs
I/O time: 0.000795 sec
Total time: 0.0499699 secs
I/O time: 0.000794 sec
Total time: 0.047987 secs
I/O time: 0.000858 sec
Total time: 0.0488791 secs
I/O time: 0.000805 sec
Total time: 0.0474229 secs
I/O time: 0.001341 sec
Total time: 0.0483899 secs
I/O time: 0.000789 sec
Total time: 0.049283 secs
I/O time: 0.000807 sec
Total time: 0.0486999 secs
I/O time: 0.000771 sec
Total time: 0.0487032 secs
   96 |     990 |      15 |  0.062468239 |        ideal
I/O time: 0.000797 sec
Total time: 0.0478652 secs
I/O time: 0.000847 sec
Total time: 0.048085 secs
I/O time: 0.000787 sec
```

```
Total time: 0.0475841 secs
I/O time: 0.000768 sec
Total time: 0.0477979 secs
I/O time: 0.000804 sec
Total time: 0.048928 secs
I/O time: 0.000779 sec
Total time: 0.0473478 secs
I/O time: 0.000785 sec
Total time: 0.0467451 secs
I/O time: 0.001312 sec
Total time: 0.049716 secs
I/O time: 0.000770 sec
Total time: 0.0532851 secs
I/O time: 0.000786 sec
Total time: 0.048491 secs
   97 |    1000 |      15 |  0.00000E+00 |            f
I/O time: 0.000840 sec
Total time: 0.049098 secs
I/O time: 0.000812 sec
Total time: 0.047842 secs
I/O time: 0.000793 sec
Total time: 0.047483 secs
I/O time: 0.001251 sec
Total time: 0.0476739 secs
I/O time: 0.000802 sec
Total time: 0.049123 secs
I/O time: 0.000855 sec
Total time: 0.0495632 secs
I/O time: 0.000808 sec
Total time: 0.0476289 secs
I/O time: 0.000823 sec
Total time: 0.050076 secs
I/O time: 0.000770 sec
Total time: 0.0483601 secs
I/O time: 0.001340 sec
Total time: 0.0505071 secs
   98 |    1010 |      17 |  0.002111840 |            f
I/O time: 0.000920 sec
Total time: 0.0500531 secs
I/O time: 0.001052 sec
Total time: 0.052515 secs
I/O time: 0.000787 sec
Total time: 0.048548 secs
I/O time: 0.000781 sec
Total time: 0.0485988 secs
I/O time: 0.000873 sec
Total time: 0.048805 secs
I/O time: 0.000796 sec
```

```
Total time: 0.0469301 secs
I/O time: 0.000886 sec
Total time: 0.0494568 secs
I/O time: 0.000775 sec
Total time: 0.0493059 secs
I/O time: 0.000789 sec
Total time: 0.0478959 secs
I/O time: 0.000803 sec
Total time: 0.051136 secs
   99 |    1020 |      17 |  0.00000E+00 |            f
I/O time: 0.000780 sec
Total time: 0.0490429 secs
I/O time: 0.000823 sec
Total time: 0.0470769 secs
I/O time: 0.000809 sec
Total time: 0.0492411 secs
I/O time: 0.001247 sec
Total time: 0.049098 secs
I/O time: 0.000797 sec
Total time: 0.0481679 secs
I/O time: 0.000860 sec
Total time: 0.0494559 secs
I/O time: 0.000776 sec
Total time: 0.0484831 secs
I/O time: 0.000768 sec
Total time: 0.0512569 secs
I/O time: 0.000801 sec
Total time: 0.0479369 secs
I/O time: 0.000805 sec
Total time: 0.0485451 secs
  100 |    1030 |      18 |  0.001550741 |            f
Time taken 447.1898412704468 seconds.
Optimising A-P
I/O time: 0.000889 sec
Total time: 0.044857 secs
I/O time: 0.000780 sec
Total time: 0.021667 secs
I/O time: 0.000771 sec
Total time: 0.024205 secs
I/O time: 0.000779 sec
Total time: 0.0267119 secs
I/O time: 0.000788 sec
Total time: 0.0429921 secs
I/O time: 0.000794 sec
Total time: 0.0426919 secs
I/O time: 0.000865 sec
Total time: 0.038841 secs
I/O time: 0.000792 sec
```

```
Total time: 0.028326 secs
I/O time: 0.000815 sec
Total time: 0.0457959 secs
I/O time: 0.000784 sec
Total time: 0.025481 secs
I/O time: 0.000830 sec
Total time: 0.0357411 secs
I/O time: 0.000796 sec
Total time: 0.044425 secs
I/O time: 0.000775 sec
Total time: 0.0319932 secs
I/O time: 0.000778 sec
Total time: 0.019803 secs
I/O time: 0.000861 sec
Total time: 0.0361731 secs
I/O time: 0.001331 sec
Total time: 0.025492 secs
I/O time: 0.000843 sec
Total time: 0.024014 secs
I/O time: 0.000769 sec
Total time: 0.030386 secs
I/O time: 0.000801 sec
Total time: 0.0394859 secs
I/O time: 0.000788 sec
Total time: 0.0265789 secs
I/O time: 0.000793 sec
Total time: 0.023895 secs
I/O time: 0.000771 sec
Total time: 0.0417941 secs
I/O time: 0.000786 sec
Total time: 0.0263739 secs
I/O time: 0.000774 sec
Total time: 0.0228958 secs
I/O time: 0.000783 sec
Total time: 0.0299859 secs
I/O time: 0.000827 sec
Total time: 0.0275679 secs
I/O time: 0.000799 sec
Total time: 0.0290539 secs
I/O time: 0.001184 sec
Total time: 0.0308669 secs
I/O time: 0.000776 sec
Total time: 0.031934 secs
I/O time: 0.000815 sec
Total time: 0.0420089 secs
I/O time: 0.000793 sec
Total time: 0.0250578 secs
I/O time: 0.000783 sec
```

```
Total time: 0.0323541 secs
I/O time: 0.000798 sec
Total time: 0.0253119 secs
I/O time: 0.000788 sec
Total time: 0.0390251 secs
I/O time: 0.000770 sec
Total time: 0.028507 secs
I/O time: 0.000776 sec
Total time: 0.02316 secs
I/O time: 0.000832 sec
Total time: 0.0403719 secs
I/O time: 0.000774 sec
Total time: 0.0323761 secs
I/O time: 0.000994 sec
Total time: 0.0203121 secs
I/O time: 0.000791 sec
Total time: 0.035213 secs
=====================================================
n_gen |  n_eval |  n_nds  |     eps      |  indicator
=====================================================
    1 |      40 |       6 |            - |            -
I/O time: 0.000777 sec
Total time: 0.0311821 secs
I/O time: 0.000815 sec
Total time: 0.0293 secs
I/O time: 0.000779 sec
Total time: 0.0197072 secs
I/O time: 0.001043 sec
Total time: 0.039851 secs
I/O time: 0.000783 sec
Total time: 0.0410261 secs
I/O time: 0.000767 sec
Total time: 0.0233788 secs
I/O time: 0.001158 sec
Total time: 0.0352271 secs
I/O time: 0.000779 sec
Total time: 0.0196471 secs
I/O time: 0.000779 sec
Total time: 0.0265911 secs
I/O time: 0.000905 sec
Total time: 0.044188 secs
    2 |      50 |       9 |  0.035583403 |        ideal
I/O time: 0.001437 sec
Total time: 0.0438261 secs
I/O time: 0.000767 sec
Total time: 0.0288291 secs
I/O time: 0.000882 sec
Total time: 0.0452881 secs
```

```
I/O time: 0.000779 sec
Total time: 0.0446122 secs
I/O time: 0.000795 sec
Total time: 0.0277948 secs
I/O time: 0.000777 sec
Total time: 0.045115 secs
I/O time: 0.000801 sec
Total time: 0.036298 secs
I/O time: 0.000793 sec
Total time: 0.0298231 secs
I/O time: 0.000796 sec
Total time: 0.0405581 secs
I/O time: 0.000777 sec
Total time: 0.030699 secs
    3 |      60 |      10 |  0.032654365 |            f
I/O time: 0.000775 sec
Total time: 0.0201478 secs
I/O time: 0.000871 sec
Total time: 0.0223291 secs
I/O time: 0.000768 sec
Total time: 0.046839 secs
I/O time: 0.000788 sec
Total time: 0.0431659 secs
I/O time: 0.000766 sec
Total time: 0.0303321 secs
I/O time: 0.000799 sec
Total time: 0.023047 secs
I/O time: 0.000780 sec
Total time: 0.0430241 secs
I/O time: 0.000780 sec
Total time: 0.0431778 secs
I/O time: 0.000778 sec
Total time: 0.0251601 secs
I/O time: 0.000780 sec
Total time: 0.024703 secs
    4 |      70 |      10 |  0.125321056 |        ideal
I/O time: 0.000783 sec
Total time: 0.0242729 secs
I/O time: 0.000786 sec
Total time: 0.0316629 secs
I/O time: 0.000776 sec
Total time: 0.01929 secs
I/O time: 0.000783 sec
Total time: 0.0199828 secs
I/O time: 0.001266 sec
Total time: 0.0237632 secs
I/O time: 0.000799 sec
Total time: 0.042078 secs
```

```
I/O time: 0.000899 sec
Total time: 0.0287781 secs
I/O time: 0.000799 sec
Total time: 0.0353739 secs
I/O time: 0.000752 sec
Total time: 0.0225019 secs
I/O time: 0.000788 sec
Total time: 0.0293891 secs
    5 |      80 |      12 |  0.047166865 |        ideal
I/O time: 0.000794 sec
Total time: 0.042563 secs
I/O time: 0.000768 sec
Total time: 0.0439169 secs
I/O time: 0.000786 sec
Total time: 0.03142 secs
I/O time: 0.000762 sec
Total time: 0.0208299 secs
I/O time: 0.000806 sec
Total time: 0.031682 secs
I/O time: 0.000774 sec
Total time: 0.030421 secs
I/O time: 0.001273 sec
Total time: 0.0272739 secs
I/O time: 0.000771 sec
Total time: 0.0354049 secs
I/O time: 0.000776 sec
Total time: 0.032737 secs
I/O time: 0.000807 sec
Total time: 0.019455 secs
    6 |      90 |      11 |  0.008155669 |        ideal
I/O time: 0.000746 sec
Total time: 0.0203371 secs
I/O time: 0.000768 sec
Total time: 0.032671 secs
I/O time: 0.000765 sec
Total time: 0.0227249 secs
I/O time: 0.000793 sec
Total time: 0.0251958 secs
I/O time: 0.000750 sec
Total time: 0.030463 secs
I/O time: 0.000792 sec
Total time: 0.0255251 secs
I/O time: 0.001067 sec
Total time: 0.0404189 secs
I/O time: 0.000820 sec
Total time: 0.0461371 secs
I/O time: 0.001280 sec
Total time: 0.035589 secs
```

```
I/O time: 0.000769 sec
Total time: 0.032028 secs
    7 |     100 |      13 |  0.355066574 |        ideal
I/O time: 0.000870 sec
Total time: 0.0212231 secs
I/O time: 0.000861 sec
Total time: 0.023211 secs
I/O time: 0.000799 sec
Total time: 0.0400479 secs
I/O time: 0.000794 sec
Total time: 0.037087 secs
I/O time: 0.000783 sec
Total time: 0.0280378 secs
I/O time: 0.000778 sec
Total time: 0.0292289 secs
I/O time: 0.000791 sec
Total time: 0.0311069 secs
I/O time: 0.000812 sec
Total time: 0.0431571 secs
I/O time: 0.000788 sec
Total time: 0.0182741 secs
I/O time: 0.000749 sec
Total time: 0.0246599 secs
    8 |     110 |       7 |  0.170171429 |        ideal
I/O time: 0.001867 sec
Total time: 0.033469 secs
I/O time: 0.000769 sec
Total time: 0.020865 secs
I/O time: 0.000783 sec
Total time: 0.0435739 secs
I/O time: 0.000773 sec
Total time: 0.0281041 secs
I/O time: 0.000787 sec
Total time: 0.0451379 secs
I/O time: 0.000754 sec
Total time: 0.0309739 secs
I/O time: 0.000767 sec
Total time: 0.025733 secs
I/O time: 0.000768 sec
Total time: 0.021651 secs
I/O time: 0.000777 sec
Total time: 0.030442 secs
I/O time: 0.000787 sec
Total time: 0.0305569 secs
    9 |     120 |       7 |  0.016478040 |        nadir
I/O time: 0.000757 sec
Total time: 0.020848 secs
I/O time: 0.000771 sec
```

```
Total time: 0.023844 secs
I/O time: 0.000766 sec
Total time: 0.0234621 secs
I/O time: 0.000684 sec
Total time: 0.0269818 secs
I/O time: 0.000843 sec
Total time: 0.0445888 secs
I/O time: 0.000866 sec
Total time: 0.02512 secs
I/O time: 0.000790 sec
Total time: 0.0196612 secs
I/O time: 0.000759 sec
Total time: 0.0185828 secs
I/O time: 0.000770 sec
Total time: 0.0181739 secs
I/O time: 0.000776 sec
Total time: 0.0431302 secs
   10 |     130 |       9 |  0.263352190 |        ideal
I/O time: 0.000768 sec
Total time: 0.0199211 secs
I/O time: 0.000894 sec
Total time: 0.0444548 secs
I/O time: 0.000790 sec
Total time: 0.0289149 secs
I/O time: 0.001294 sec
Total time: 0.031862 secs
I/O time: 0.000794 sec
Total time: 0.0427041 secs
I/O time: 0.001323 sec
Total time: 0.022922 secs
I/O time: 0.000765 sec
Total time: 0.0280659 secs
I/O time: 0.000766 sec
Total time: 0.017935 secs
I/O time: 0.000780 sec
Total time: 0.020813 secs
I/O time: 0.000775 sec
Total time: 0.0311942 secs
   11 |     140 |      11 |  0.008874387 |            f
I/O time: 0.000777 sec
Total time: 0.0218198 secs
I/O time: 0.000785 sec
Total time: 0.0437429 secs
I/O time: 0.000753 sec
Total time: 0.0180452 secs
I/O time: 0.000749 sec
Total time: 0.0286531 secs
I/O time: 0.000742 sec
```

```
Total time: 0.0310972 secs
I/O time: 0.000777 sec
Total time: 0.0196362 secs
I/O time: 0.000806 sec
Total time: 0.0271659 secs
I/O time: 0.000765 sec
Total time: 0.018914 secs
I/O time: 0.000782 sec
Total time: 0.02143 secs
I/O time: 0.000791 sec
Total time: 0.0190489 secs
   12 |     150 |      13 |  0.001112547 |            f
I/O time: 0.000786 sec
Total time: 0.0272529 secs
I/O time: 0.000781 sec
Total time: 0.021843 secs
I/O time: 0.000782 sec
Total time: 0.0288539 secs
I/O time: 0.000794 sec
Total time: 0.017679 secs
I/O time: 0.000773 sec
Total time: 0.0218611 secs
I/O time: 0.001457 sec
Total time: 0.0254271 secs
I/O time: 0.000769 sec
Total time: 0.018599 secs
I/O time: 0.000757 sec
Total time: 0.030303 secs
I/O time: 0.000795 sec
Total time: 0.0436609 secs
I/O time: 0.000773 sec
Total time: 0.020472 secs
   13 |     160 |      14 |  0.020777357 |            f
I/O time: 0.000775 sec
Total time: 0.024338 secs
I/O time: 0.000785 sec
Total time: 0.0296578 secs
I/O time: 0.000772 sec
Total time: 0.0205901 secs
I/O time: 0.000774 sec
Total time: 0.034812 secs
I/O time: 0.000766 sec
Total time: 0.026484 secs
I/O time: 0.000764 sec
Total time: 0.0281661 secs
I/O time: 0.000757 sec
Total time: 0.023824 secs
I/O time: 0.000765 sec
```

```
Total time: 0.034936 secs
I/O time: 0.000762 sec
Total time: 0.028543 secs
I/O time: 0.000768 sec
Total time: 0.0248039 secs
   14 |     170 |      16 |  0.012104897 |        nadir
I/O time: 0.000779 sec
Total time: 0.0446649 secs
I/O time: 0.000783 sec
Total time: 0.0164261 secs
I/O time: 0.000806 sec
Total time: 0.0210121 secs
I/O time: 0.000781 sec
Total time: 0.022665 secs
I/O time: 0.000791 sec
Total time: 0.0303061 secs
I/O time: 0.000758 sec
Total time: 0.0243649 secs
I/O time: 0.000771 sec
Total time: 0.027905 secs
I/O time: 0.000772 sec
Total time: 0.0235009 secs
I/O time: 0.000770 sec
Total time: 0.0182171 secs
I/O time: 0.000759 sec
Total time: 0.0278111 secs
   15 |     180 |      17 |  0.010731501 |           f
I/O time: 0.000767 sec
Total time: 0.031389 secs
I/O time: 0.000771 sec
Total time: 0.0269158 secs
I/O time: 0.000757 sec
Total time: 0.0204711 secs
I/O time: 0.000843 sec
Total time: 0.023977 secs
I/O time: 0.000765 sec
Total time: 0.0218482 secs
I/O time: 0.000757 sec
Total time: 0.0271602 secs
I/O time: 0.000688 sec
Total time: 0.0448151 secs
I/O time: 0.000780 sec
Total time: 0.018203 secs
I/O time: 0.000775 sec
Total time: 0.022511 secs
I/O time: 0.000862 sec
Total time: 0.0321069 secs
   16 |     190 |      13 |  0.012253221 |        nadir
```

```
I/O time: 0.000781 sec
Total time: 0.0233271 secs
I/O time: 0.000814 sec
Total time: 0.0224671 secs
I/O time: 0.001249 sec
Total time: 0.0220399 secs
I/O time: 0.000759 sec
Total time: 0.0258331 secs
I/O time: 0.000792 sec
Total time: 0.0434291 secs
I/O time: 0.000768 sec
Total time: 0.0197139 secs
I/O time: 0.000785 sec
Total time: 0.019691 secs
I/O time: 0.000766 sec
Total time: 0.0446889 secs
I/O time: 0.000766 sec
Total time: 0.035929 secs
I/O time: 0.000786 sec
Total time: 0.0202179 secs
   17 |     200 |      14 |  0.006060603 |        nadir
I/O time: 0.000785 sec
Total time: 0.0230939 secs
I/O time: 0.000791 sec
Total time: 0.0460682 secs
I/O time: 0.000761 sec
Total time: 0.02175 secs
I/O time: 0.000763 sec
Total time: 0.0245252 secs
I/O time: 0.000774 sec
Total time: 0.0177979 secs
I/O time: 0.001448 sec
Total time: 0.0467229 secs
I/O time: 0.000774 sec
Total time: 0.016221 secs
I/O time: 0.000776 sec
Total time: 0.0222101 secs
I/O time: 0.000898 sec
Total time: 0.0237579 secs
I/O time: 0.000773 sec
Total time: 0.022068 secs
   18 |     210 |       1 |  1.677681446 |        ideal
I/O time: 0.000771 sec
Total time: 0.0231791 secs
I/O time: 0.000771 sec
Total time: 0.020889 secs
I/O time: 0.000819 sec
Total time: 0.0426788 secs
```

```
I/O time: 0.000771 sec
Total time: 0.019562 secs
I/O time: 0.000770 sec
Total time: 0.018527 secs
I/O time: 0.000745 sec
Total time: 0.0205991 secs
I/O time: 0.000793 sec
Total time: 0.0440891 secs
I/O time: 0.000781 sec
Total time: 0.0430472 secs
I/O time: 0.000775 sec
Total time: 0.0231318 secs
I/O time: 0.000823 sec
Total time: 0.0456438 secs
   19 |     220 |       1 |  0.00000E+00 |            f
I/O time: 0.000774 sec
Total time: 0.0285721 secs
I/O time: 0.000766 sec
Total time: 0.022054 secs
I/O time: 0.000756 sec
Total time: 0.031076 secs
I/O time: 0.000777 sec
Total time: 0.0178761 secs
I/O time: 0.000769 sec
Total time: 0.0238898 secs
I/O time: 0.000781 sec
Total time: 0.0285749 secs
I/O time: 0.000770 sec
Total time: 0.020627 secs
I/O time: 0.000758 sec
Total time: 0.0176129 secs
I/O time: 0.000764 sec
Total time: 0.022193 secs
I/O time: 0.001313 sec
Total time: 0.0256879 secs
   20 |     230 |       1 |  0.00000E+00 |            f
I/O time: 0.000769 sec
Total time: 0.018558 secs
I/O time: 0.000770 sec
Total time: 0.0201721 secs
I/O time: 0.000779 sec
Total time: 0.0428472 secs
I/O time: 0.000779 sec
Total time: 0.0450392 secs
I/O time: 0.000797 sec
Total time: 0.0312612 secs
I/O time: 0.000793 sec
Total time: 0.0464501 secs
```

```
I/O time: 0.000887 sec
Total time: 0.0223031 secs
I/O time: 0.000770 sec
Total time: 0.0235622 secs
I/O time: 0.000888 sec
Total time: 0.025034 secs
I/O time: 0.000758 sec
Total time: 0.0243721 secs
   21 |     240 |       1 |  0.00000E+00 |            f
I/O time: 0.000774 sec
Total time: 0.0329232 secs
I/O time: 0.001159 sec
Total time: 0.0407639 secs
I/O time: 0.000753 sec
Total time: 0.0223269 secs
I/O time: 0.000786 sec
Total time: 0.0425651 secs
I/O time: 0.000770 sec
Total time: 0.0179908 secs
I/O time: 0.000773 sec
Total time: 0.026943 secs
I/O time: 0.000884 sec
Total time: 0.0463791 secs
I/O time: 0.000765 sec
Total time: 0.0248311 secs
I/O time: 0.000780 sec
Total time: 0.0417511 secs
I/O time: 0.000816 sec
Total time: 0.0217988 secs
   22 |     250 |       1 |  0.00000E+00 |            f
I/O time: 0.000782 sec
Total time: 0.0171959 secs
I/O time: 0.000845 sec
Total time: 0.0204818 secs
I/O time: 0.000756 sec
Total time: 0.0221169 secs
I/O time: 0.003012 sec
Total time: 0.022361 secs
I/O time: 0.000752 sec
Total time: 0.0176089 secs
I/O time: 0.000785 sec
Total time: 0.023989 secs
I/O time: 0.000845 sec
Total time: 0.025614 secs
I/O time: 0.000786 sec
Total time: 0.0259039 secs
I/O time: 0.000761 sec
Total time: 0.017585 secs
```

```
I/O time: 0.000757 sec
Total time: 0.016552 secs
   23 |     260 |       1 |  0.00000E+00 |            f
I/O time: 0.000774 sec
Total time: 0.0273969 secs
I/O time: 0.000754 sec
Total time: 0.016917 secs
I/O time: 0.000766 sec
Total time: 0.0216019 secs
I/O time: 0.000781 sec
Total time: 0.0480771 secs
I/O time: 0.000771 sec
Total time: 0.0241539 secs
I/O time: 0.000764 sec
Total time: 0.0278451 secs
I/O time: 0.001356 sec
Total time: 0.022006 secs
I/O time: 0.000788 sec
Total time: 0.023741 secs
I/O time: 0.000774 sec
Total time: 0.0229471 secs
I/O time: 0.000757 sec
Total time: 0.0196352 secs
   24 |     270 |       1 |  0.00000E+00 |            f
I/O time: 0.000767 sec
Total time: 0.0435331 secs
I/O time: 0.000771 sec
Total time: 0.0237391 secs
I/O time: 0.000770 sec
Total time: 0.0240471 secs
I/O time: 0.000763 sec
Total time: 0.0180111 secs
I/O time: 0.000747 sec
Total time: 0.0233769 secs
I/O time: 0.000816 sec
Total time: 0.0444322 secs
I/O time: 0.000754 sec
Total time: 0.026731 secs
I/O time: 0.000764 sec
Total time: 0.0393829 secs
I/O time: 0.000759 sec
Total time: 0.024755 secs
I/O time: 0.001180 sec
Total time: 0.027946 secs
   25 |     280 |       2 |  1.000000000 |        ideal
I/O time: 0.000769 sec
Total time: 0.0185642 secs
I/O time: 0.000772 sec
```

```
Total time: 0.0244029 secs
I/O time: 0.000699 sec
Total time: 0.0317221 secs
I/O time: 0.000762 sec
Total time: 0.0251231 secs
I/O time: 0.000767 sec
Total time: 0.016614 secs
I/O time: 0.000773 sec
Total time: 0.0216389 secs
I/O time: 0.000759 sec
Total time: 0.0157912 secs
I/O time: 0.000748 sec
Total time: 0.0346148 secs
I/O time: 0.000760 sec
Total time: 0.0218189 secs
I/O time: 0.000771 sec
Total time: 0.0430501 secs
   26 |     290 |       2 |  0.00000E+00 |            f
I/O time: 0.000775 sec
Total time: 0.0194421 secs
I/O time: 0.001235 sec
Total time: 0.0448081 secs
I/O time: 0.000789 sec
Total time: 0.043119 secs
I/O time: 0.000753 sec
Total time: 0.0187371 secs
I/O time: 0.000774 sec
Total time: 0.0207319 secs
I/O time: 0.000764 sec
Total time: 0.0461299 secs
I/O time: 0.000780 sec
Total time: 0.0439811 secs
I/O time: 0.001384 sec
Total time: 0.024848 secs
I/O time: 0.000783 sec
Total time: 0.022929 secs
I/O time: 0.000762 sec
Total time: 0.021836 secs
   27 |     300 |       2 |  0.00000E+00 |            f
I/O time: 0.000836 sec
Total time: 0.0451128 secs
I/O time: 0.000782 sec
Total time: 0.0223241 secs
I/O time: 0.000754 sec
Total time: 0.016551 secs
I/O time: 0.000864 sec
Total time: 0.04356 secs
I/O time: 0.004848 sec
```

```
Total time: 0.0245309 secs
I/O time: 0.000782 sec
Total time: 0.015981 secs
I/O time: 0.000854 sec
Total time: 0.048275 secs
I/O time: 0.000761 sec
Total time: 0.022166 secs
I/O time: 0.000768 sec
Total time: 0.043735 secs
I/O time: 0.001003 sec
Total time: 0.043021 secs
   28 |     310 |       3 |  0.00000E+00 |            f
I/O time: 0.000791 sec
Total time: 0.0432401 secs
I/O time: 0.000774 sec
Total time: 0.041749 secs
I/O time: 0.000778 sec
Total time: 0.0449581 secs
I/O time: 0.001206 sec
Total time: 0.0457561 secs
I/O time: 0.000754 sec
Total time: 0.0195789 secs
I/O time: 0.000831 sec
Total time: 0.01685 secs
I/O time: 0.001449 sec
Total time: 0.0431821 secs
I/O time: 0.000919 sec
Total time: 0.0429499 secs
I/O time: 0.000771 sec
Total time: 0.0208659 secs
I/O time: 0.000703 sec
Total time: 0.0448239 secs
   29 |     320 |       3 |  0.00000E+00 |            f
I/O time: 0.000783 sec
Total time: 0.0185859 secs
I/O time: 0.001158 sec
Total time: 0.0478899 secs
I/O time: 0.000776 sec
Total time: 0.0297022 secs
I/O time: 0.000787 sec
Total time: 0.044359 secs
I/O time: 0.001246 sec
Total time: 0.0446 secs
I/O time: 0.000777 sec
Total time: 0.0455859 secs
I/O time: 0.000879 sec
Total time: 0.0451138 secs
I/O time: 0.000782 sec
```

```
Total time: 0.026593 secs
I/O time: 0.000793 sec
Total time: 0.044868 secs
I/O time: 0.000755 sec
Total time: 0.0200851 secs
   30 |     330 |       1 |  0.833493948 |        ideal
I/O time: 0.000793 sec
Total time: 0.043792 secs
I/O time: 0.000779 sec
Total time: 0.0431771 secs
I/O time: 0.000759 sec
Total time: 0.0204098 secs
I/O time: 0.001461 sec
Total time: 0.0432961 secs
I/O time: 0.000774 sec
Total time: 0.0433619 secs
I/O time: 0.000863 sec
Total time: 0.045326 secs
I/O time: 0.000767 sec
Total time: 0.0452831 secs
I/O time: 0.000886 sec
Total time: 0.042094 secs
I/O time: 0.000755 sec
Total time: 0.0427058 secs
I/O time: 0.000814 sec
Total time: 0.042882 secs
   31 |     340 |       1 |  0.00000E+00 |            f
I/O time: 0.000777 sec
Total time: 0.0237198 secs
I/O time: 0.001152 sec
Total time: 0.0438471 secs
I/O time: 0.000777 sec
Total time: 0.0420668 secs
I/O time: 0.001179 sec
Total time: 0.046267 secs
I/O time: 0.000778 sec
Total time: 0.0184269 secs
I/O time: 0.000763 sec
Total time: 0.0297971 secs
I/O time: 0.000786 sec
Total time: 0.0449948 secs
I/O time: 0.000780 sec
Total time: 0.0434961 secs
I/O time: 0.000940 sec
Total time: 0.045526 secs
I/O time: 0.000791 sec
Total time: 0.045557 secs
   32 |     350 |       1 |  0.00000E+00 |            f
```

```
I/O time: 0.000845 sec
Total time: 0.04456 secs
I/O time: 0.000775 sec
Total time: 0.054044 secs
I/O time: 0.000782 sec
Total time: 0.0427771 secs
I/O time: 0.000781 sec
Total time: 0.042877 secs
I/O time: 0.000775 sec
Total time: 0.0439332 secs
I/O time: 0.001244 sec
Total time: 0.044723 secs
I/O time: 0.000864 sec
Total time: 0.0456851 secs
I/O time: 0.001227 sec
Total time: 0.0436881 secs
I/O time: 0.000752 sec
Total time: 0.0250711 secs
I/O time: 0.001009 sec
Total time: 0.044929 secs
   33 |     360 |       1 |  0.00000E+00 |            f
I/O time: 0.000752 sec
Total time: 0.017159 secs
I/O time: 0.001137 sec
Total time: 0.0437539 secs
I/O time: 0.000765 sec
Total time: 0.0440938 secs
I/O time: 0.001286 sec
Total time: 0.0447249 secs
I/O time: 0.000760 sec
Total time: 0.0434141 secs
I/O time: 0.000779 sec
Total time: 0.018995 secs
I/O time: 0.000834 sec
Total time: 0.0447838 secs
I/O time: 0.000775 sec
Total time: 0.0443931 secs
I/O time: 0.000771 sec
Total time: 0.0435061 secs
I/O time: 0.001143 sec
Total time: 0.0445731 secs
   34 |     370 |       1 |  0.00000E+00 |            f
I/O time: 0.001379 sec
Total time: 0.0447319 secs
I/O time: 0.000784 sec
Total time: 0.0439811 secs
I/O time: 0.000773 sec
Total time: 0.044724 secs
```

```
I/O time: 0.001314 sec
Total time: 0.0459039 secs
I/O time: 0.000803 sec
Total time: 0.044013 secs
I/O time: 0.001330 sec
Total time: 0.045754 secs
I/O time: 0.001331 sec
Total time: 0.04512 secs
I/O time: 0.000774 sec
Total time: 0.0520051 secs
I/O time: 0.001274 sec
Total time: 0.0442941 secs
I/O time: 0.001235 sec
Total time: 0.0446129 secs
   35 |     380 |       1 |  0.00000E+00 |            f
I/O time: 0.001096 sec
Total time: 0.0439019 secs
I/O time: 0.000811 sec
Total time: 0.0437648 secs
I/O time: 0.000767 sec
Total time: 0.04475 secs
I/O time: 0.000773 sec
Total time: 0.039104 secs
I/O time: 0.000796 sec
Total time: 0.043997 secs
I/O time: 0.000771 sec
Total time: 0.042995 secs
I/O time: 0.000946 sec
Total time: 0.044724 secs
I/O time: 0.000783 sec
Total time: 0.043344 secs
I/O time: 0.000780 sec
Total time: 0.0427499 secs
I/O time: 0.000849 sec
Total time: 0.0442958 secs
   36 |     390 |       1 |  0.044484615 |        ideal
I/O time: 0.000867 sec
Total time: 0.04389 secs
I/O time: 0.000784 sec
Total time: 0.044364 secs
I/O time: 0.000877 sec
Total time: 0.0466349 secs
I/O time: 0.000905 sec
Total time: 0.0448759 secs
I/O time: 0.000773 sec
Total time: 0.0427849 secs
I/O time: 0.001139 sec
Total time: 0.0451 secs
```

```
I/O time: 0.000783 sec
Total time: 0.044944 secs
I/O time: 0.000769 sec
Total time: 0.0458579 secs
I/O time: 0.000771 sec
Total time: 0.0455401 secs
I/O time: 0.001249 sec
Total time: 0.0449519 secs
   37 |     400 |       1 |  0.00000E+00 |            f
I/O time: 0.000792 sec
Total time: 0.044641 secs
I/O time: 0.000804 sec
Total time: 0.0439789 secs
I/O time: 0.000862 sec
Total time: 0.0478351 secs
I/O time: 0.000770 sec
Total time: 0.0445518 secs
I/O time: 0.001238 sec
Total time: 0.04443 secs
I/O time: 0.000780 sec
Total time: 0.0424869 secs
I/O time: 0.000862 sec
Total time: 0.044796 secs
I/O time: 0.001265 sec
Total time: 0.0448899 secs
I/O time: 0.000806 sec
Total time: 0.0449359 secs
I/O time: 0.000756 sec
Total time: 0.048069 secs
   38 |     410 |       1 |  0.00000E+00 |            f
I/O time: 0.000786 sec
Total time: 0.045691 secs
I/O time: 0.001216 sec
Total time: 0.045481 secs
I/O time: 0.000785 sec
Total time: 0.0455799 secs
I/O time: 0.000811 sec
Total time: 0.0433929 secs
I/O time: 0.000795 sec
Total time: 0.045254 secs
I/O time: 0.000781 sec
Total time: 0.0443161 secs
I/O time: 0.000782 sec
Total time: 0.0442669 secs
I/O time: 0.000789 sec
Total time: 0.0444849 secs
I/O time: 0.000813 sec
Total time: 0.0428751 secs
```

```
I/O time: 0.000793 sec
Total time: 0.042315 secs
   39 |     420 |       2 |  1.000000000 |        ideal
I/O time: 0.001258 sec
Total time: 0.0432181 secs
I/O time: 0.000787 sec
Total time: 0.0430071 secs
I/O time: 0.001268 sec
Total time: 0.044565 secs
I/O time: 0.001756 sec
Total time: 0.042546 secs
I/O time: 0.001266 sec
Total time: 0.0435901 secs
I/O time: 0.000765 sec
Total time: 0.044647 secs
I/O time: 0.001255 sec
Total time: 0.0418751 secs
I/O time: 0.000785 sec
Total time: 0.0438871 secs
I/O time: 0.000768 sec
Total time: 0.0436819 secs
I/O time: 0.000968 sec
Total time: 0.0431652 secs
   40 |     430 |       2 |  0.00000E+00 |            f
I/O time: 0.000772 sec
Total time: 0.0449471 secs
I/O time: 0.000770 sec
Total time: 0.0437679 secs
I/O time: 0.000771 sec
Total time: 0.0447371 secs
I/O time: 0.001123 sec
Total time: 0.0431211 secs
I/O time: 0.000777 sec
Total time: 0.0439239 secs
I/O time: 0.000774 sec
Total time: 0.043978 secs
I/O time: 0.000786 sec
Total time: 0.0427849 secs
I/O time: 0.000901 sec
Total time: 0.044806 secs
I/O time: 0.000901 sec
Total time: 0.0449479 secs
I/O time: 0.001910 sec
Total time: 0.045867 secs
   41 |     440 |       2 |  0.00000E+00 |            f
I/O time: 0.001241 sec
Total time: 0.0452189 secs
I/O time: 0.000768 sec
```

```
Total time: 0.0450029 secs
I/O time: 0.000820 sec
Total time: 0.0442379 secs
I/O time: 0.000775 sec
Total time: 0.043366 secs
I/O time: 0.000781 sec
Total time: 0.0437171 secs
I/O time: 0.000778 sec
Total time: 0.042706 secs
I/O time: 0.000842 sec
Total time: 0.045954 secs
I/O time: 0.000857 sec
Total time: 0.045126 secs
I/O time: 0.000915 sec
Total time: 0.0456491 secs
I/O time: 0.000785 sec
Total time: 0.044872 secs
   42 |     450 |       3 |  0.123610109 |            f
I/O time: 0.000778 sec
Total time: 0.0433638 secs
I/O time: 0.001261 sec
Total time: 0.046073 secs
I/O time: 0.000817 sec
Total time: 0.04684 secs
I/O time: 0.000777 sec
Total time: 0.0458951 secs
I/O time: 0.000782 sec
Total time: 0.0450301 secs
I/O time: 0.000859 sec
Total time: 0.0445662 secs
I/O time: 0.000798 sec
Total time: 0.0477111 secs
I/O time: 0.000893 sec
Total time: 0.0441329 secs
I/O time: 0.000770 sec
Total time: 0.0460761 secs
I/O time: 0.000922 sec
Total time: 0.0445349 secs
   43 |     460 |       4 |  0.006038885 |        ideal
I/O time: 0.001151 sec
Total time: 0.0454299 secs
I/O time: 0.000897 sec
Total time: 0.0446041 secs
I/O time: 0.000796 sec
Total time: 0.045105 secs
I/O time: 0.001273 sec
Total time: 0.0455742 secs
I/O time: 0.000783 sec
```

```
Total time: 0.0446522 secs
I/O time: 0.000766 sec
Total time: 0.0490789 secs
I/O time: 0.000912 sec
Total time: 0.0443912 secs
I/O time: 0.000890 sec
Total time: 0.0449171 secs
I/O time: 0.000856 sec
Total time: 0.0439031 secs
I/O time: 0.000788 sec
Total time: 0.0427709 secs
   44 |     470 |       5 |  0.614817573 |        ideal
I/O time: 0.000803 sec
Total time: 0.0441091 secs
I/O time: 0.000770 sec
Total time: 0.0429809 secs
I/O time: 0.000811 sec
Total time: 0.0440631 secs
I/O time: 0.000785 sec
Total time: 0.0459409 secs
I/O time: 0.000779 sec
Total time: 0.0434361 secs
I/O time: 0.001251 sec
Total time: 0.052036 secs
I/O time: 0.000865 sec
Total time: 0.0442901 secs
I/O time: 0.000768 sec
Total time: 0.04617 secs
I/O time: 0.000773 sec
Total time: 0.0443671 secs
I/O time: 0.000793 sec
Total time: 0.044045 secs
   45 |     480 |       5 |  0.00000E+00 |            f
I/O time: 0.000803 sec
Total time: 0.0423028 secs
I/O time: 0.000866 sec
Total time: 0.0465171 secs
I/O time: 0.000880 sec
Total time: 0.0434411 secs
I/O time: 0.000786 sec
Total time: 0.0453 secs
I/O time: 0.000840 sec
Total time: 0.045027 secs
I/O time: 0.000887 sec
Total time: 0.045053 secs
I/O time: 0.000931 sec
Total time: 0.0432069 secs
I/O time: 0.001443 sec
```

```
Total time: 0.0484331 secs
I/O time: 0.000770 sec
Total time: 0.045192 secs
I/O time: 0.001418 sec
Total time: 0.0450869 secs
   46 |     490 |       5 |  0.00000E+00 |            f
I/O time: 0.000804 sec
Total time: 0.0447769 secs
I/O time: 0.000890 sec
Total time: 0.0445309 secs
I/O time: 0.000780 sec
Total time: 0.043262 secs
I/O time: 0.000792 sec
Total time: 0.043148 secs
I/O time: 0.000774 sec
Total time: 0.0443821 secs
I/O time: 0.000783 sec
Total time: 0.043627 secs
I/O time: 0.000869 sec
Total time: 0.0417681 secs
I/O time: 0.000777 sec
Total time: 0.0444548 secs
I/O time: 0.000782 sec
Total time: 0.0454869 secs
I/O time: 0.000796 sec
Total time: 0.044538 secs
   47 |     500 |       5 |  0.00000E+00 |            f
I/O time: 0.000833 sec
Total time: 0.0452681 secs
I/O time: 0.000795 sec
Total time: 0.0443151 secs
I/O time: 0.000783 sec
Total time: 0.045213 secs
I/O time: 0.000719 sec
Total time: 0.047693 secs
I/O time: 0.001264 sec
Total time: 0.0453229 secs
I/O time: 0.000780 sec
Total time: 0.0460241 secs
I/O time: 0.000777 sec
Total time: 0.0440931 secs
I/O time: 0.000780 sec
Total time: 0.0437751 secs
I/O time: 0.000886 sec
Total time: 0.0451128 secs
I/O time: 0.001251 sec
Total time: 0.0446861 secs
   48 |     510 |       5 |  0.00000E+00 |            f
```

```
I/O time: 0.000777 sec
Total time: 0.045778 secs
I/O time: 0.000768 sec
Total time: 0.044203 secs
I/O time: 0.000778 sec
Total time: 0.0437682 secs
I/O time: 0.000772 sec
Total time: 0.0490699 secs
I/O time: 0.000786 sec
Total time: 0.0451839 secs
I/O time: 0.000792 sec
Total time: 0.0457702 secs
I/O time: 0.000807 sec
Total time: 0.043669 secs
I/O time: 0.001273 sec
Total time: 0.0446041 secs
I/O time: 0.000791 sec
Total time: 0.0438311 secs
I/O time: 0.000788 sec
Total time: 0.0428751 secs
   49 |     520 |       5 |  0.00000E+00 |            f
I/O time: 0.000789 sec
Total time: 0.042202 secs
I/O time: 0.001279 sec
Total time: 0.045644 secs
I/O time: 0.000825 sec
Total time: 0.045398 secs
I/O time: 0.000773 sec
Total time: 0.044261 secs
I/O time: 0.000776 sec
Total time: 0.0432072 secs
I/O time: 0.000867 sec
Total time: 0.046351 secs
I/O time: 0.001011 sec
Total time: 0.045625 secs
I/O time: 0.000784 sec
Total time: 0.0434821 secs
I/O time: 0.001624 sec
Total time: 0.0448651 secs
I/O time: 0.000786 sec
Total time: 0.0431449 secs
   50 |     530 |       5 |  0.00000E+00 |            f
I/O time: 0.000877 sec
Total time: 0.044735 secs
I/O time: 0.000772 sec
Total time: 0.0428309 secs
I/O time: 0.000798 sec
Total time: 0.044039 secs
```

```
I/O time: 0.001292 sec
Total time: 0.044538 secs
I/O time: 0.000768 sec
Total time: 0.049531 secs
I/O time: 0.000790 sec
Total time: 0.04318 secs
I/O time: 0.000891 sec
Total time: 0.051666 secs
I/O time: 0.000880 sec
Total time: 0.0453329 secs
I/O time: 0.001371 sec
Total time: 0.0440311 secs
I/O time: 0.000827 sec
Total time: 0.0417941 secs
   51 |     540 |       7 |  0.038587411 |        nadir
I/O time: 0.000783 sec
Total time: 0.0436709 secs
I/O time: 0.000776 sec
Total time: 0.045368 secs
I/O time: 0.000762 sec
Total time: 0.0440769 secs
I/O time: 0.000764 sec
Total time: 0.0438659 secs
I/O time: 0.001144 sec
Total time: 0.044311 secs
I/O time: 0.004225 sec
Total time: 0.046942 secs
I/O time: 0.000779 sec
Total time: 0.0491941 secs
I/O time: 0.000773 sec
Total time: 0.0450721 secs
I/O time: 0.000976 sec
Total time: 0.0442369 secs
I/O time: 0.000781 sec
Total time: 0.0440872 secs
   52 |     550 |       7 |  0.00000E+00 |            f
I/O time: 0.000779 sec
Total time: 0.0440559 secs
I/O time: 0.000812 sec
Total time: 0.0428779 secs
I/O time: 0.000907 sec
Total time: 0.044693 secs
I/O time: 0.000781 sec
Total time: 0.0468402 secs
I/O time: 0.001243 sec
Total time: 0.044884 secs
I/O time: 0.001006 sec
Total time: 0.0420361 secs
```

```
I/O time: 0.000786 sec
Total time: 0.0453241 secs
I/O time: 0.001430 sec
Total time: 0.0459199 secs
I/O time: 0.000874 sec
Total time: 0.0444472 secs
I/O time: 0.000686 sec
Total time: 0.045532 secs
   53 |     560 |       7 |  0.00000E+00 |            f
I/O time: 0.000819 sec
Total time: 0.045789 secs
I/O time: 0.000692 sec
Total time: 0.0451479 secs
I/O time: 0.000783 sec
Total time: 0.0445571 secs
I/O time: 0.000852 sec
Total time: 0.0460849 secs
I/O time: 0.000846 sec
Total time: 0.044601 secs
I/O time: 0.000793 sec
Total time: 0.045419 secs
I/O time: 0.000883 sec
Total time: 0.0456908 secs
I/O time: 0.000782 sec
Total time: 0.0462809 secs
I/O time: 0.000850 sec
Total time: 0.042078 secs
I/O time: 0.000785 sec
Total time: 0.043731 secs
   54 |     570 |       7 |  0.00000E+00 |            f
I/O time: 0.000746 sec
Total time: 0.04599 secs
I/O time: 0.000778 sec
Total time: 0.0447519 secs
I/O time: 0.000896 sec
Total time: 0.0446942 secs
I/O time: 0.000783 sec
Total time: 0.0444331 secs
I/O time: 0.000780 sec
Total time: 0.040843 secs
I/O time: 0.000929 sec
Total time: 0.0471458 secs
I/O time: 0.000755 sec
Total time: 0.044723 secs
I/O time: 0.001381 sec
Total time: 0.0446372 secs
I/O time: 0.000803 sec
Total time: 0.043458 secs
```

```
I/O time: 0.000797 sec
Total time: 0.0446889 secs
   55 |     580 |       2 |  0.098648780 |        ideal
I/O time: 0.000884 sec
Total time: 0.0449471 secs
I/O time: 0.000763 sec
Total time: 0.044091 secs
I/O time: 0.000777 sec
Total time: 0.044086 secs
I/O time: 0.000788 sec
Total time: 0.0452402 secs
I/O time: 0.000779 sec
Total time: 0.045042 secs
I/O time: 0.000774 sec
Total time: 0.044126 secs
I/O time: 0.000848 sec
Total time: 0.0440629 secs
I/O time: 0.000782 sec
Total time: 0.0451279 secs
I/O time: 0.000886 sec
Total time: 0.0441821 secs
I/O time: 0.000766 sec
Total time: 0.0438731 secs
   56 |     590 |       2 |  0.00000E+00 |            f
I/O time: 0.000800 sec
Total time: 0.044148 secs
I/O time: 0.000776 sec
Total time: 0.0526509 secs
I/O time: 0.000769 sec
Total time: 0.0423558 secs
I/O time: 0.001178 sec
Total time: 0.0431781 secs
I/O time: 0.000889 sec
Total time: 0.0445781 secs
I/O time: 0.000789 sec
Total time: 0.047627 secs
I/O time: 0.000787 sec
Total time: 0.043613 secs
I/O time: 0.000850 sec
Total time: 0.043973 secs
I/O time: 0.000787 sec
Total time: 0.0432091 secs
I/O time: 0.000786 sec
Total time: 0.0525391 secs
   57 |     600 |       2 |  0.00000E+00 |            f
I/O time: 0.000784 sec
Total time: 0.0447421 secs
I/O time: 0.000785 sec
```

```
Total time: 0.0435002 secs
I/O time: 0.000890 sec
Total time: 0.0452571 secs
I/O time: 0.000791 sec
Total time: 0.0639741 secs
I/O time: 0.000777 sec
Total time: 0.0627401 secs
I/O time: 0.000769 sec
Total time: 0.0462239 secs
I/O time: 0.000839 sec
Total time: 0.051528 secs
I/O time: 0.001124 sec
Total time: 0.0446119 secs
I/O time: 0.000777 sec
Total time: 0.0440021 secs
I/O time: 0.000781 sec
Total time: 0.0444729 secs
   58 |     610 |       2 |  0.00000E+00 |            f
I/O time: 0.000789 sec
Total time: 0.0438759 secs
I/O time: 0.000778 sec
Total time: 0.0452311 secs
I/O time: 0.000779 sec
Total time: 0.0457728 secs
I/O time: 0.000753 sec
Total time: 0.0495169 secs
I/O time: 0.000806 sec
Total time: 0.047662 secs
I/O time: 0.000791 sec
Total time: 0.0436749 secs
I/O time: 0.000829 sec
Total time: 0.043988 secs
I/O time: 0.000781 sec
Total time: 0.045917 secs
I/O time: 0.000784 sec
Total time: 0.043627 secs
I/O time: 0.000894 sec
Total time: 0.045475 secs
   59 |     620 |       3 |  0.065883081 |        ideal
I/O time: 0.000792 sec
Total time: 0.0438509 secs
I/O time: 0.000776 sec
Total time: 0.0434968 secs
I/O time: 0.000776 sec
Total time: 0.045886 secs
I/O time: 0.000775 sec
Total time: 0.0433629 secs
I/O time: 0.001249 sec
```

```
Total time: 0.044848 secs
I/O time: 0.000784 sec
Total time: 0.0442929 secs
I/O time: 0.000776 sec
Total time: 0.0430129 secs
I/O time: 0.000780 sec
Total time: 0.0430691 secs
I/O time: 0.000785 sec
Total time: 0.045743 secs
I/O time: 0.000770 sec
Total time: 0.0456462 secs
   60 |     630 |       3 |  0.00000E+00 |            f
I/O time: 0.000787 sec
Total time: 0.044127 secs
I/O time: 0.000835 sec
Total time: 0.0446901 secs
I/O time: 0.000974 sec
Total time: 0.045573 secs
I/O time: 0.000778 sec
Total time: 0.0444522 secs
I/O time: 0.000785 sec
Total time: 0.0422881 secs
I/O time: 0.000870 sec
Total time: 0.0452399 secs
I/O time: 0.000761 sec
Total time: 0.042654 secs
I/O time: 0.000867 sec
Total time: 0.0441289 secs
I/O time: 0.000771 sec
Total time: 0.043751 secs
I/O time: 0.000791 sec
Total time: 0.0467131 secs
   61 |     640 |       3 |  0.00000E+00 |            f
I/O time: 0.000775 sec
Total time: 0.0444448 secs
I/O time: 0.000789 sec
Total time: 0.043829 secs
I/O time: 0.000799 sec
Total time: 0.0456541 secs
I/O time: 0.000784 sec
Total time: 0.0435979 secs
I/O time: 0.000795 sec
Total time: 0.048645 secs
I/O time: 0.000829 sec
Total time: 0.044615 secs
I/O time: 0.000792 sec
Total time: 0.0442188 secs
I/O time: 0.000777 sec
```

```
Total time: 0.0435679 secs
I/O time: 0.000776 sec
Total time: 0.0458729 secs
I/O time: 0.000848 sec
Total time: 0.0448809 secs
   62 |     650 |       1 |  0.030351184 |        ideal
I/O time: 0.000911 sec
Total time: 0.045398 secs
I/O time: 0.000770 sec
Total time: 0.045002 secs
I/O time: 0.000819 sec
Total time: 0.0436461 secs
I/O time: 0.000768 sec
Total time: 0.0429821 secs
I/O time: 0.000770 sec
Total time: 0.0470471 secs
I/O time: 0.000777 sec
Total time: 0.0434499 secs
I/O time: 0.000780 sec
Total time: 0.0444841 secs
I/O time: 0.000757 sec
Total time: 0.0544131 secs
I/O time: 0.000892 sec
Total time: 0.0448968 secs
I/O time: 0.001316 sec
Total time: 0.04443 secs
   63 |     660 |       2 |  1.000000000 |        ideal
I/O time: 0.000784 sec
Total time: 0.044035 secs
I/O time: 0.000775 sec
Total time: 0.0448701 secs
I/O time: 0.000772 sec
Total time: 0.043942 secs
I/O time: 0.000782 sec
Total time: 0.0487511 secs
I/O time: 0.000880 sec
Total time: 0.0444028 secs
I/O time: 0.001381 sec
Total time: 0.0448589 secs
I/O time: 0.000955 sec
Total time: 0.0459871 secs
I/O time: 0.000804 sec
Total time: 0.044698 secs
I/O time: 0.001867 sec
Total time: 0.0470049 secs
I/O time: 0.000777 sec
Total time: 0.0440772 secs
   64 |     670 |       3 |  0.00000E+00 |           f
```

```
I/O time: 0.000770 sec
Total time: 0.0413611 secs
I/O time: 0.000791 sec
Total time: 0.043452 secs
I/O time: 0.000769 sec
Total time: 0.0444901 secs
I/O time: 0.000802 sec
Total time: 0.0435681 secs
I/O time: 0.000777 sec
Total time: 0.0443778 secs
I/O time: 0.000786 sec
Total time: 0.042325 secs
I/O time: 0.000780 sec
Total time: 0.053941 secs
I/O time: 0.000783 sec
Total time: 0.0459361 secs
I/O time: 0.000888 sec
Total time: 0.044838 secs
I/O time: 0.000783 sec
Total time: 0.043761 secs
   65 |     680 |       3 |  0.00000E+00 |            f
I/O time: 0.000775 sec
Total time: 0.043081 secs
I/O time: 0.000789 sec
Total time: 0.0451019 secs
I/O time: 0.000803 sec
Total time: 0.044452 secs
I/O time: 0.000933 sec
Total time: 0.0450308 secs
I/O time: 0.000791 sec
Total time: 0.0447569 secs
I/O time: 0.000779 sec
Total time: 0.0453062 secs
I/O time: 0.000801 sec
Total time: 0.042002 secs
I/O time: 0.000792 sec
Total time: 0.042774 secs
I/O time: 0.000783 sec
Total time: 0.0455072 secs
I/O time: 0.001276 sec
Total time: 0.0444911 secs
   66 |     690 |       4 |  0.144503406 |        nadir
I/O time: 0.000892 sec
Total time: 0.046468 secs
I/O time: 0.000887 sec
Total time: 0.0427592 secs
I/O time: 0.000841 sec
Total time: 0.0442162 secs
```

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I/O time: 0.000799 sec
Total time: 0.044353 secs
I/O time: 0.000822 sec
Total time: 0.0448232 secs
I/O time: 0.000896 sec
Total time: 0.045908 secs
I/O time: 0.000784 sec
Total time: 0.0449109 secs
I/O time: 0.000928 sec
Total time: 0.0448589 secs
I/O time: 0.001136 sec
Total time: 0.0454471 secs
I/O time: 0.000802 sec
Total time: 0.055706 secs
   67 |     700 |       4 |  0.00000E+00 |            f
I/O time: 0.000754 sec
Total time: 0.044029 secs
I/O time: 0.000777 sec
Total time: 0.0430491 secs
I/O time: 0.000790 sec
Total time: 0.0445881 secs
I/O time: 0.000833 sec
Total time: 0.0427089 secs
I/O time: 0.000792 sec
Total time: 0.0430162 secs
I/O time: 0.000893 sec
Total time: 0.045584 secs
I/O time: 0.000820 sec
Total time: 0.0456169 secs
I/O time: 0.000897 sec
Total time: 0.0456181 secs
I/O time: 0.000765 sec
Total time: 0.0506859 secs
I/O time: 0.000889 sec
Total time: 0.045141 secs
   68 |     710 |       4 |  0.00000E+00 |            f
I/O time: 0.000781 sec
Total time: 0.0458739 secs
I/O time: 0.000862 sec
Total time: 0.0446849 secs
I/O time: 0.000798 sec
Total time: 0.0430889 secs
I/O time: 0.000824 sec
Total time: 0.0469971 secs
I/O time: 0.000770 sec
Total time: 0.0452268 secs
I/O time: 0.000894 sec
Total time: 0.046088 secs
```

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I/O time: 0.000897 sec
Total time: 0.0459628 secs
I/O time: 0.000784 sec
Total time: 0.0461378 secs
I/O time: 0.000812 sec
Total time: 0.046304 secs
I/O time: 0.000898 sec
Total time: 0.0451849 secs
   69 |     720 |       4 |  0.00000E+00 |            f
I/O time: 0.001003 sec
Total time: 0.0447311 secs
I/O time: 0.000789 sec
Total time: 0.0452349 secs
I/O time: 0.000787 sec
Total time: 0.0495231 secs
I/O time: 0.000891 sec
Total time: 0.0437319 secs
I/O time: 0.000775 sec
Total time: 0.044209 secs
I/O time: 0.000804 sec
Total time: 0.0424371 secs
I/O time: 0.001043 sec
Total time: 0.0437 secs
I/O time: 0.000786 sec
Total time: 0.0427918 secs
I/O time: 0.000765 sec
Total time: 0.042259 secs
I/O time: 0.000793 sec
Total time: 0.046144 secs
   70 |     730 |       1 |  0.075283557 |        ideal
I/O time: 0.000862 sec
Total time: 0.0452371 secs
I/O time: 0.000847 sec
Total time: 0.0436361 secs
I/O time: 0.000787 sec
Total time: 0.045258 secs
I/O time: 0.000815 sec
Total time: 0.042253 secs
I/O time: 0.000850 sec
Total time: 0.0457332 secs
I/O time: 0.000794 sec
Total time: 0.043535 secs
I/O time: 0.001321 sec
Total time: 0.044919 secs
I/O time: 0.000774 sec
Total time: 0.045352 secs
I/O time: 0.000776 sec
Total time: 0.042484 secs
```

```
I/O time: 0.000853 sec
Total time: 0.04526 secs
   71 |     740 |       1 |  0.00000E+00 |            f
I/O time: 0.000829 sec
Total time: 0.0445712 secs
I/O time: 0.000791 sec
Total time: 0.043222 secs
I/O time: 0.000789 sec
Total time: 0.0434222 secs
I/O time: 0.001390 sec
Total time: 0.0441282 secs
I/O time: 0.000781 sec
Total time: 0.0434659 secs
I/O time: 0.000796 sec
Total time: 0.0444551 secs
I/O time: 0.001004 sec
Total time: 0.044574 secs
I/O time: 0.000776 sec
Total time: 0.0478551 secs
I/O time: 0.000793 sec
Total time: 0.0450039 secs
I/O time: 0.001028 sec
Total time: 0.042311 secs
   72 |     750 |       1 |  0.00000E+00 |            f
I/O time: 0.000841 sec
Total time: 0.044277 secs
I/O time: 0.000849 sec
Total time: 0.0444031 secs
I/O time: 0.000785 sec
Total time: 0.0438092 secs
I/O time: 0.000786 sec
Total time: 0.0436411 secs
I/O time: 0.000781 sec
Total time: 0.0438631 secs
I/O time: 0.000777 sec
Total time: 0.0454569 secs
I/O time: 0.000788 sec
Total time: 0.0437989 secs
I/O time: 0.000785 sec
Total time: 0.049798 secs
I/O time: 0.000785 sec
Total time: 0.0410161 secs
I/O time: 0.000846 sec
Total time: 0.0462549 secs
   73 |     760 |       1 |  0.00000E+00 |            f
I/O time: 0.000787 sec
Total time: 0.0449059 secs
I/O time: 0.000930 sec
```

```
Total time: 0.0452912 secs
I/O time: 0.000792 sec
Total time: 0.042773 secs
I/O time: 0.000759 sec
Total time: 0.0431921 secs
I/O time: 0.000764 sec
Total time: 0.056313 secs
I/O time: 0.000775 sec
Total time: 0.04389 secs
I/O time: 0.000769 sec
Total time: 0.04317 secs
I/O time: 0.001373 sec
Total time: 0.046279 secs
I/O time: 0.000792 sec
Total time: 0.0424941 secs
I/O time: 0.000781 sec
Total time: 0.0443981 secs
   74 |     770 |       1 |  0.00000E+00 |            f
I/O time: 0.000898 sec
Total time: 0.046066 secs
I/O time: 0.000810 sec
Total time: 0.0457249 secs
I/O time: 0.000762 sec
Total time: 0.043654 secs
I/O time: 0.000843 sec
Total time: 0.043833 secs
I/O time: 0.000791 sec
Total time: 0.0427742 secs
I/O time: 0.000888 sec
Total time: 0.045758 secs
I/O time: 0.000784 sec
Total time: 0.0440319 secs
I/O time: 0.000791 sec
Total time: 0.0448768 secs
I/O time: 0.000816 sec
Total time: 0.0435531 secs
I/O time: 0.000781 sec
Total time: 0.0442739 secs
   75 |     780 |       1 |  0.00000E+00 |            f
I/O time: 0.000797 sec
Total time: 0.0458279 secs
I/O time: 0.000823 sec
Total time: 0.0445271 secs
I/O time: 0.000897 sec
Total time: 0.0447509 secs
I/O time: 0.000786 sec
Total time: 0.0432811 secs
I/O time: 0.000899 sec
```

```
Total time: 0.0419252 secs
I/O time: 0.000802 sec
Total time: 0.0450861 secs
I/O time: 0.000768 sec
Total time: 0.0441818 secs
I/O time: 0.001243 sec
Total time: 0.0446041 secs
I/O time: 0.001158 sec
Total time: 0.043004 secs
I/O time: 0.000804 sec
Total time: 0.0449009 secs
   76 |     790 |       1 |  0.00000E+00 |            f
I/O time: 0.000742 sec
Total time: 0.04546 secs
I/O time: 0.000908 sec
Total time: 0.0464771 secs
I/O time: 0.000799 sec
Total time: 0.04318 secs
I/O time: 0.000788 sec
Total time: 0.0460279 secs
I/O time: 0.000869 sec
Total time: 0.0458958 secs
I/O time: 0.000775 sec
Total time: 0.046911 secs
I/O time: 0.000888 sec
Total time: 0.0454741 secs
I/O time: 0.000794 sec
Total time: 0.0447631 secs
I/O time: 0.000877 sec
Total time: 0.046361 secs
I/O time: 0.000873 sec
Total time: 0.045846 secs
   77 |     800 |       1 |  0.00000E+00 |            f
I/O time: 0.000791 sec
Total time: 0.0437641 secs
I/O time: 0.000787 sec
Total time: 0.043319 secs
I/O time: 0.001272 sec
Total time: 0.045224 secs
I/O time: 0.001429 sec
Total time: 0.045619 secs
I/O time: 0.000855 sec
Total time: 0.0443659 secs
I/O time: 0.000905 sec
Total time: 0.0445681 secs
I/O time: 0.000800 sec
Total time: 0.0444422 secs
I/O time: 0.000827 sec
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```
Total time: 0.0439701 secs
I/O time: 0.000787 sec
Total time: 0.0450511 secs
I/O time: 0.000911 sec
Total time: 0.0436959 secs
   78 |     810 |       1 |  0.00000E+00 |            f
I/O time: 0.000796 sec
Total time: 0.044256 secs
I/O time: 0.000893 sec
Total time: 0.0442801 secs
I/O time: 0.000781 sec
Total time: 0.043303 secs
I/O time: 0.000783 sec
Total time: 0.043407 secs
I/O time: 0.000927 sec
Total time: 0.046113 secs
I/O time: 0.000783 sec
Total time: 0.042371 secs
I/O time: 0.000791 sec
Total time: 0.051645 secs
I/O time: 0.000780 sec
Total time: 0.0454719 secs
I/O time: 0.000908 sec
Total time: 0.0451968 secs
I/O time: 0.000777 sec
Total time: 0.0431321 secs
   79 |     820 |       1 |  0.00000E+00 |            f
I/O time: 0.001248 sec
Total time: 0.045747 secs
I/O time: 0.000786 sec
Total time: 0.0445781 secs
I/O time: 0.000780 sec
Total time: 0.0422761 secs
I/O time: 0.000848 sec
Total time: 0.0446811 secs
I/O time: 0.000896 sec
Total time: 0.0451281 secs
I/O time: 0.000779 sec
Total time: 0.042661 secs
I/O time: 0.001375 sec
Total time: 0.0474141 secs
I/O time: 0.000840 sec
Total time: 0.046088 secs
I/O time: 0.000793 sec
Total time: 0.0467131 secs
I/O time: 0.000792 sec
Total time: 0.0438681 secs
   80 |     830 |       1 |  0.00000E+00 |            f
```

```
I/O time: 0.000796 sec
Total time: 0.0438101 secs
I/O time: 0.000801 sec
Total time: 0.047724 secs
I/O time: 0.000776 sec
Total time: 0.0468709 secs
I/O time: 0.000894 sec
Total time: 0.0439491 secs
I/O time: 0.000828 sec
Total time: 0.04426 secs
I/O time: 0.000775 sec
Total time: 0.04649 secs
I/O time: 0.000792 sec
Total time: 0.042335 secs
I/O time: 0.000785 sec
Total time: 0.0498769 secs
I/O time: 0.000913 sec
Total time: 0.0445409 secs
I/O time: 0.000785 sec
Total time: 0.0435998 secs
   81 |     840 |       1 |  0.00000E+00 |            f
I/O time: 0.000780 sec
Total time: 0.043582 secs
I/O time: 0.000794 sec
Total time: 0.045018 secs
I/O time: 0.000885 sec
Total time: 0.0439088 secs
I/O time: 0.001256 sec
Total time: 0.0427551 secs
I/O time: 0.000777 sec
Total time: 0.042922 secs
I/O time: 0.000782 sec
Total time: 0.043499 secs
I/O time: 0.000910 sec
Total time: 0.0444028 secs
I/O time: 0.000783 sec
Total time: 0.0451269 secs
I/O time: 0.000847 sec
Total time: 0.0441992 secs
I/O time: 0.000805 sec
Total time: 0.0435169 secs
   82 |     850 |       1 |  0.00000E+00 |            f
I/O time: 0.001651 sec
Total time: 0.0439639 secs
I/O time: 0.000776 sec
Total time: 0.0445979 secs
I/O time: 0.000778 sec
Total time: 0.0518901 secs
```

```
I/O time: 0.000778 sec
Total time: 0.0449839 secs
I/O time: 0.000788 sec
Total time: 0.044224 secs
I/O time: 0.000915 sec
Total time: 0.0462811 secs
I/O time: 0.000760 sec
Total time: 0.04515 secs
I/O time: 0.000784 sec
Total time: 0.044646 secs
I/O time: 0.000788 sec
Total time: 0.0433359 secs
I/O time: 0.000793 sec
Total time: 0.044821 secs
   83 |     860 |       1 |  0.00000E+00 |            f
I/O time: 0.000779 sec
Total time: 0.0430682 secs
I/O time: 0.000777 sec
Total time: 0.0439332 secs
I/O time: 0.001400 sec
Total time: 0.0454609 secs
I/O time: 0.000781 sec
Total time: 0.0435078 secs
I/O time: 0.000813 sec
Total time: 0.0434132 secs
I/O time: 0.000909 sec
Total time: 0.0454929 secs
I/O time: 0.000789 sec
Total time: 0.0448689 secs
I/O time: 0.000780 sec
Total time: 0.0450459 secs
I/O time: 0.000821 sec
Total time: 0.0431612 secs
I/O time: 0.000872 sec
Total time: 0.0454659 secs
   84 |     870 |       1 |  0.00000E+00 |            f
I/O time: 0.000782 sec
Total time: 0.0389352 secs
I/O time: 0.001263 sec
Total time: 0.0438809 secs
I/O time: 0.000807 sec
Total time: 0.042697 secs
I/O time: 0.000776 sec
Total time: 0.0438969 secs
I/O time: 0.001096 sec
Total time: 0.0488279 secs
I/O time: 0.000922 sec
Total time: 0.0446749 secs
```

```
I/O time: 0.000781 sec
Total time: 0.044657 secs
I/O time: 0.000869 sec
Total time: 0.045511 secs
I/O time: 0.000784 sec
Total time: 0.0455179 secs
I/O time: 0.000791 sec
Total time: 0.042779 secs
   85 |     880 |       1 |  0.00000E+00 |            f
I/O time: 0.000790 sec
Total time: 0.0447991 secs
I/O time: 0.000873 sec
Total time: 0.046098 secs
I/O time: 0.000765 sec
Total time: 0.0442879 secs
I/O time: 0.000791 sec
Total time: 0.0449212 secs
I/O time: 0.000786 sec
Total time: 0.0591302 secs
I/O time: 0.000779 sec
Total time: 0.044436 secs
I/O time: 0.000760 sec
Total time: 0.0457489 secs
I/O time: 0.000786 sec
Total time: 0.045505 secs
I/O time: 0.000905 sec
Total time: 0.0447261 secs
I/O time: 0.001280 sec
Total time: 0.0462339 secs
   86 |     890 |       1 |  0.00000E+00 |            f
I/O time: 0.000900 sec
Total time: 0.044987 secs
I/O time: 0.000959 sec
Total time: 0.0446539 secs
I/O time: 0.000783 sec
Total time: 0.0435951 secs
I/O time: 0.000785 sec
Total time: 0.0445251 secs
I/O time: 0.000801 sec
Total time: 0.0487058 secs
I/O time: 0.000900 sec
Total time: 0.044903 secs
I/O time: 0.001518 sec
Total time: 0.0462542 secs
I/O time: 0.000795 sec
Total time: 0.043813 secs
I/O time: 0.000812 sec
Total time: 0.0472701 secs
```

```
I/O time: 0.000786 sec
Total time: 0.043015 secs
   87 |     900 |       1 |  0.00000E+00 |            f
I/O time: 0.010321 sec
Total time: 0.0538371 secs
I/O time: 0.000790 sec
Total time: 0.0437999 secs
I/O time: 0.000881 sec
Total time: 0.0450099 secs
I/O time: 0.000790 sec
Total time: 0.0456419 secs
I/O time: 0.000797 sec
Total time: 0.0430989 secs
I/O time: 0.000867 sec
Total time: 0.0437181 secs
I/O time: 0.000805 sec
Total time: 0.0468721 secs
I/O time: 0.000801 sec
Total time: 0.044415 secs
I/O time: 0.000779 sec
Total time: 0.045028 secs
I/O time: 0.000780 sec
Total time: 0.044214 secs
   88 |     910 |       1 |  0.00000E+00 |            f
I/O time: 0.000788 sec
Total time: 0.043654 secs
I/O time: 0.000883 sec
Total time: 0.0447469 secs
I/O time: 0.016155 sec
Total time: 0.0584509 secs
I/O time: 0.000792 sec
Total time: 0.044899 secs
I/O time: 0.000804 sec
Total time: 0.0435061 secs
I/O time: 0.000792 sec
Total time: 0.042532 secs
I/O time: 0.000926 sec
Total time: 0.0454419 secs
I/O time: 0.000949 sec
Total time: 0.042753 secs
I/O time: 0.000957 sec
Total time: 0.0468779 secs
I/O time: 0.017808 sec
Total time: 0.062721 secs
   89 |     920 |       1 |  0.00000E+00 |            f
I/O time: 0.000777 sec
Total time: 0.0463028 secs
I/O time: 0.001226 sec
```

```
Total time: 0.0458789 secs
I/O time: 0.000804 sec
Total time: 0.043355 secs
I/O time: 0.000801 sec
Total time: 0.0428059 secs
I/O time: 0.001297 sec
Total time: 0.045577 secs
I/O time: 0.000802 sec
Total time: 0.045311 secs
I/O time: 0.000796 sec
Total time: 0.0425491 secs
I/O time: 0.000804 sec
Total time: 0.046813 secs
I/O time: 0.000793 sec
Total time: 0.0457549 secs
I/O time: 0.000786 sec
Total time: 0.044163 secs
   90 |     930 |       1 |  0.00000E+00 |            f
I/O time: 0.000794 sec
Total time: 0.0446889 secs
I/O time: 0.000800 sec
Total time: 0.0475981 secs
I/O time: 0.000782 sec
Total time: 0.045763 secs
I/O time: 0.001563 sec
Total time: 0.0446188 secs
I/O time: 0.000881 sec
Total time: 0.0448492 secs
I/O time: 0.000797 sec
Total time: 0.0463309 secs
I/O time: 0.000916 sec
Total time: 0.04563 secs
I/O time: 0.000885 sec
Total time: 0.046067 secs
I/O time: 0.000919 sec
Total time: 0.045094 secs
I/O time: 0.000793 sec
Total time: 0.04298 secs
   91 |     940 |       1 |  0.00000E+00 |            f
I/O time: 0.000804 sec
Total time: 0.0454121 secs
I/O time: 0.000797 sec
Total time: 0.0434921 secs
I/O time: 0.000791 sec
Total time: 0.0441692 secs
I/O time: 0.000802 sec
Total time: 0.0452461 secs
I/O time: 0.000878 sec
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Total time: 0.0447972 secs
I/O time: 0.001521 sec
Total time: 0.045377 secs
I/O time: 0.000784 sec
Total time: 0.0404861 secs
I/O time: 0.000808 sec
Total time: 0.0429091 secs
I/O time: 0.000787 sec
Total time: 0.04406 secs
I/O time: 0.000784 sec
Total time: 0.0446889 secs
   92 |     950 |       2 |  1.000000000 |        ideal
I/O time: 0.000799 sec
Total time: 0.0429649 secs
I/O time: 0.000810 sec
Total time: 0.044446 secs
I/O time: 0.000789 sec
Total time: 0.0434802 secs
I/O time: 0.000785 sec
Total time: 0.0426881 secs
I/O time: 0.000794 sec
Total time: 0.0487001 secs
I/O time: 0.000786 sec
Total time: 0.0438371 secs
I/O time: 0.001277 sec
Total time: 0.045656 secs
I/O time: 0.001745 sec
Total time: 0.045512 secs
I/O time: 0.000758 sec
Total time: 0.041935 secs
I/O time: 0.001250 sec
Total time: 0.0440369 secs
   93 |     960 |       2 |  0.00000E+00 |            f
I/O time: 0.000795 sec
Total time: 0.044831 secs
I/O time: 0.000785 sec
Total time: 0.0432942 secs
I/O time: 0.000853 sec
Total time: 0.0463569 secs
I/O time: 0.000782 sec
Total time: 0.0467939 secs
I/O time: 0.000788 sec
Total time: 0.0437889 secs
I/O time: 0.000848 sec
Total time: 0.0451999 secs
I/O time: 0.000789 sec
Total time: 0.04177 secs
I/O time: 0.000790 sec
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```
Total time: 0.0429261 secs
I/O time: 0.000776 sec
Total time: 0.0433428 secs
I/O time: 0.001310 sec
Total time: 0.0468311 secs
   94 |     970 |       2 |  0.00000E+00 |            f
I/O time: 0.000782 sec
Total time: 0.0428851 secs
I/O time: 0.000909 sec
Total time: 0.0446839 secs
I/O time: 0.000792 sec
Total time: 0.0443668 secs
I/O time: 0.000837 sec
Total time: 0.044337 secs
I/O time: 0.000856 sec
Total time: 0.044076 secs
I/O time: 0.000801 sec
Total time: 0.0437059 secs
I/O time: 0.001250 sec
Total time: 0.0447059 secs
I/O time: 0.000786 sec
Total time: 0.0456722 secs
I/O time: 0.000779 sec
Total time: 0.0429931 secs
I/O time: 0.000789 sec
Total time: 0.0429029 secs
   95 |     980 |       2 |  0.00000E+00 |            f
I/O time: 0.000854 sec
Total time: 0.0449371 secs
I/O time: 0.000898 sec
Total time: 0.0436909 secs
I/O time: 0.000794 sec
Total time: 0.044121 secs
I/O time: 0.000803 sec
Total time: 0.043859 secs
I/O time: 0.000850 sec
Total time: 0.04547 secs
I/O time: 0.001263 sec
Total time: 0.0456879 secs
I/O time: 0.000850 sec
Total time: 0.0478971 secs
I/O time: 0.000786 sec
Total time: 0.0433428 secs
I/O time: 0.000773 sec
Total time: 0.0446651 secs
I/O time: 0.000819 sec
Total time: 0.0484679 secs
   96 |     990 |       2 |  0.00000E+00 |            f
```

```
I/O time: 0.000858 sec
Total time: 0.045326 secs
I/O time: 0.000815 sec
Total time: 0.04494 secs
I/O time: 0.001782 sec
Total time: 0.0477049 secs
I/O time: 0.000774 sec
Total time: 0.045392 secs
I/O time: 0.000805 sec
Total time: 0.0441542 secs
I/O time: 0.001269 sec
Total time: 0.0451031 secs
I/O time: 0.000908 sec
Total time: 0.045192 secs
I/O time: 0.000802 sec
Total time: 0.045274 secs
I/O time: 0.000778 sec
Total time: 0.04494 secs
I/O time: 0.000902 sec
Total time: 0.0456481 secs
   97 |    1000 |       2 |  0.00000E+00 |            f
I/O time: 0.000773 sec
Total time: 0.048383 secs
I/O time: 0.000790 sec
Total time: 0.0428638 secs
I/O time: 0.000810 sec
Total time: 0.043905 secs
I/O time: 0.000810 sec
Total time: 0.0461261 secs
I/O time: 0.001213 sec
Total time: 0.0421109 secs
I/O time: 0.000778 sec
Total time: 0.0514052 secs
I/O time: 0.000786 sec
Total time: 0.0446041 secs
I/O time: 0.000786 sec
Total time: 0.0436909 secs
I/O time: 0.000795 sec
Total time: 0.0447221 secs
I/O time: 0.000783 sec
Total time: 0.0453911 secs
   98 |    1010 |       3 |  0.024830609 |        ideal
I/O time: 0.000904 sec
Total time: 0.0449729 secs
I/O time: 0.000775 sec
Total time: 0.045156 secs
I/O time: 0.000798 sec
Total time: 0.0445139 secs
```

```
I/O time: 0.000862 sec
Total time: 0.0442159 secs
I/O time: 0.001322 sec
Total time: 0.0453939 secs
I/O time: 0.000778 sec
Total time: 0.0441918 secs
I/O time: 0.001302 sec
Total time: 0.04441 secs
I/O time: 0.001134 sec
Total time: 0.042259 secs
I/O time: 0.000774 sec
Total time: 0.0440168 secs
I/O time: 0.000991 sec
Total time: 0.0461848 secs
   99 |    1020 |       3 |  0.00000E+00 |            f
I/O time: 0.005166 sec
Total time: 0.048737 secs
I/O time: 0.000757 sec
Total time: 0.0431519 secs
I/O time: 0.000884 sec
Total time: 0.0452058 secs
I/O time: 0.000777 sec
Total time: 0.04336 secs
I/O time: 0.000829 sec
Total time: 0.046242 secs
I/O time: 0.000802 sec
Total time: 0.0447741 secs
I/O time: 0.000793 sec
Total time: 0.045049 secs
I/O time: 0.000850 sec
Total time: 0.0455 secs
I/O time: 0.002830 sec
Total time: 0.0479939 secs
I/O time: 0.000903 sec
Total time: 0.0451319 secs
  100 |    1030 |       3 |  0.00000E+00 |            f
Time taken 441.0739417076111 seconds.
```

[36]:
```python
print("Optimum c for right to left", f"{res_rl.X[0][0]:.2f}", ",", f"{ res_rl.
 ↪X[0][1]:.2f}")
print("Optimum c for anterior to posterior", f"{res_ap.X[0][0]:.2f}", ",", f"{␣
 ↪res_ap.X[0][1]:.2f}")

runtimes_drr_rl = []
runtimes_drr_ap = []

for i in range(50):
```

```
    start_time = datetime.datetime.now()

    DRR_RL = doLungmanDRRNumpy(1, 0, 0,
                               res_rl.X[0][0], res_rl.X[0][1],
                                 "DRR_RL"
                                );

    end_time = datetime.datetime.now()
    delta_time = end_time - start_time
    runtimes_drr_rl.append(delta_time.total_seconds() * 1000)

    start_time = datetime.datetime.now()

    DRR_AP = doLungmanDRRNumpy(0, -1, 0,
                                res_ap.X[0][0], res_ap.X[0][1],
                                   "DRR_AP"
                                 );

    end_time = datetime.datetime.now()
    delta_time = end_time - start_time
    runtimes_drr_ap.append(delta_time.total_seconds() * 1000)

normImage(DRR_RL)
normImage(DRR_AP)
displayLinearPowerScales(DRR_RL,  "Lungman DRR (Right to left)", "plots/
 ↪R_L_lungman_radiograph");
displayLinearPowerScales(DRR_AP,  "Lungman DRR (Anterior to posterior)", "plots/
 ↪A_P_lungman_radiograph");
```

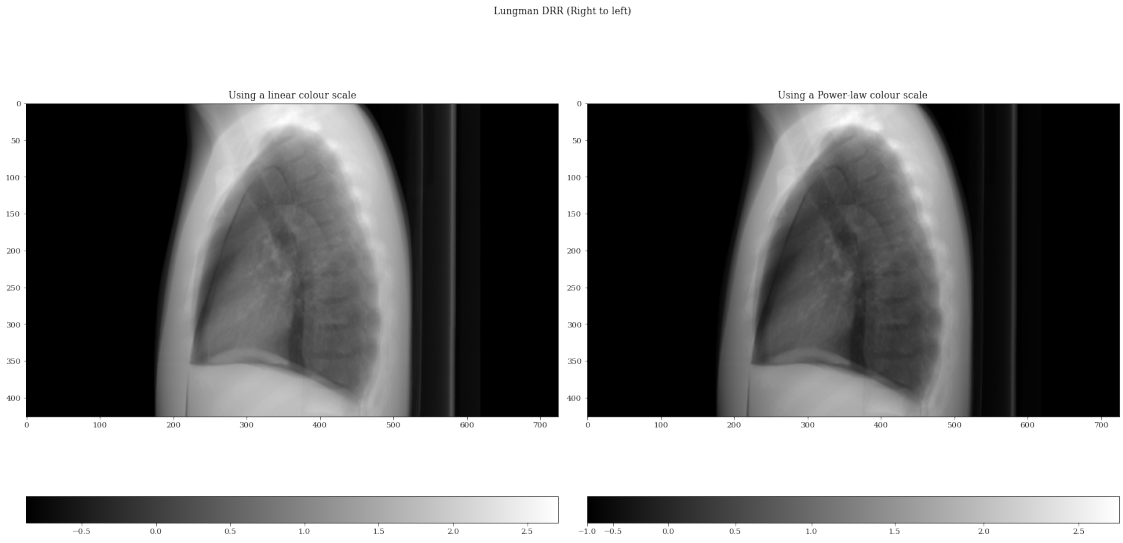
```
Optimum c for right to left 577.46 , -57.38
Optimum c for anterior to posterior 349.38 , -59.17
I/O time: 0.000792 sec
Total time: 0.0477881 secs
I/O time: 0.000843 sec
Total time: 0.045208 secs
I/O time: 0.000800 sec
Total time: 0.049135 secs
I/O time: 0.000892 sec
Total time: 0.043803 secs
I/O time: 0.000786 sec
Total time: 0.049438 secs
I/O time: 0.000775 sec
Total time: 0.0447829 secs
I/O time: 0.000890 sec
Total time: 0.0491488 secs
I/O time: 0.000786 sec
Total time: 0.043669 secs
```

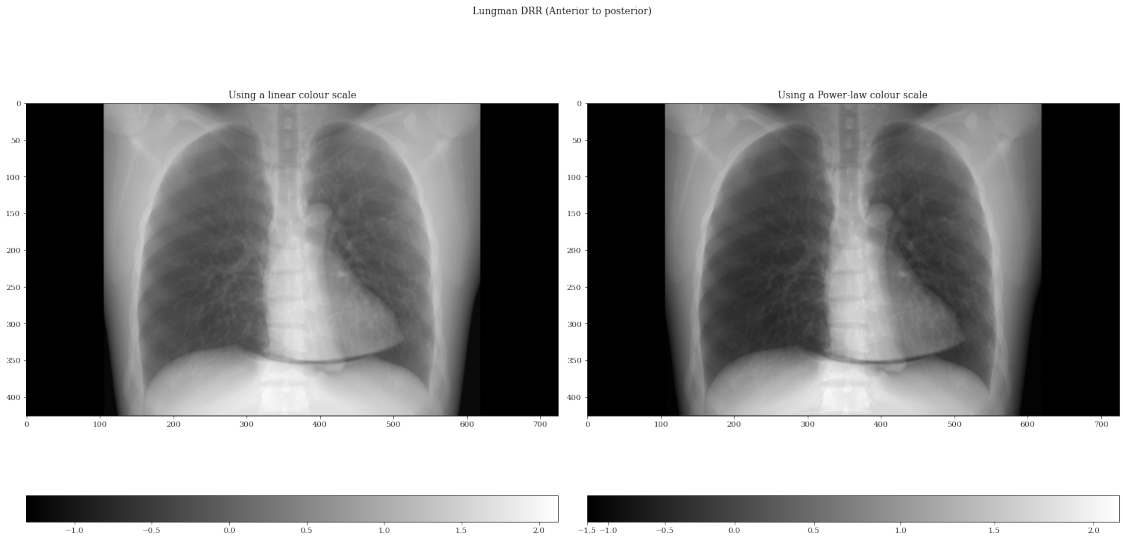
```
I/O time: 0.000784 sec
Total time: 0.049366 secs
I/O time: 0.000815 sec
Total time: 0.0445008 secs
I/O time: 0.000806 sec
Total time: 0.0503211 secs
I/O time: 0.000784 sec
Total time: 0.042871 secs
I/O time: 0.001795 sec
Total time: 0.0504129 secs
I/O time: 0.000819 sec
Total time: 0.0446181 secs
I/O time: 0.000788 sec
Total time: 0.0490761 secs
I/O time: 0.000758 sec
Total time: 0.0566161 secs
I/O time: 0.000787 sec
Total time: 0.0471179 secs
I/O time: 0.000777 sec
Total time: 0.0460191 secs
I/O time: 0.000693 sec
Total time: 0.052088 secs
I/O time: 0.000793 sec
Total time: 0.0428591 secs
I/O time: 0.000896 sec
Total time: 0.049053 secs
I/O time: 0.000919 sec
Total time: 0.0452299 secs
I/O time: 0.000868 sec
Total time: 0.0498281 secs
I/O time: 0.000794 sec
Total time: 0.043762 secs
I/O time: 0.000803 sec
Total time: 0.04985 secs
I/O time: 0.000826 sec
Total time: 0.0444901 secs
I/O time: 0.001375 sec
Total time: 0.049037 secs
I/O time: 0.000797 sec
Total time: 0.0451291 secs
I/O time: 0.000937 sec
Total time: 0.056257 secs
I/O time: 0.000790 sec
Total time: 0.0455601 secs
I/O time: 0.000879 sec
Total time: 0.050179 secs
I/O time: 0.000778 sec
Total time: 0.046875 secs
```

```
I/O time: 0.000781 sec
Total time: 0.0488698 secs
I/O time: 0.000779 sec
Total time: 0.043252 secs
I/O time: 0.000893 sec
Total time: 0.0486498 secs
I/O time: 0.001108 sec
Total time: 0.044785 secs
I/O time: 0.000778 sec
Total time: 0.0493598 secs
I/O time: 0.000786 sec
Total time: 0.0457819 secs
I/O time: 0.000778 sec
Total time: 0.050034 secs
I/O time: 0.000785 sec
Total time: 0.0429571 secs
I/O time: 0.001519 sec
Total time: 0.0492642 secs
I/O time: 0.000880 sec
Total time: 0.0445981 secs
I/O time: 0.000775 sec
Total time: 0.0486171 secs
I/O time: 0.000800 sec
Total time: 0.0437932 secs
I/O time: 0.000825 sec
Total time: 0.0503838 secs
I/O time: 0.000859 sec
Total time: 0.0447719 secs
I/O time: 0.000777 sec
Total time: 0.0482969 secs
I/O time: 0.000889 sec
Total time: 0.044786 secs
I/O time: 0.000801 sec
Total time: 0.050179 secs
I/O time: 0.000859 sec
Total time: 0.0445371 secs
I/O time: 0.000815 sec
Total time: 0.0499799 secs
I/O time: 0.000787 sec
Total time: 0.0449061 secs
I/O time: 0.001412 sec
Total time: 0.0493169 secs
I/O time: 0.000771 sec
Total time: 0.0427289 secs
I/O time: 0.000895 sec
Total time: 0.0479941 secs
I/O time: 0.000886 sec
Total time: 0.0441961 secs
```

```
I/O time: 0.000780 sec
Total time: 0.0472989 secs
I/O time: 0.000811 sec
Total time: 0.0437551 secs
I/O time: 0.000786 sec
Total time: 0.048641 secs
I/O time: 0.000779 sec
Total time: 0.0456672 secs
I/O time: 0.000785 sec
Total time: 0.0484772 secs
I/O time: 0.000832 sec
Total time: 0.044323 secs
I/O time: 0.000784 sec
Total time: 0.050117 secs
I/O time: 0.000794 sec
Total time: 0.0445969 secs
I/O time: 0.001202 sec
Total time: 0.0465989 secs
I/O time: 0.000775 sec
Total time: 0.0465 secs
I/O time: 0.000763 sec
Total time: 0.0493331 secs
I/O time: 0.000845 sec
Total time: 0.0446479 secs
I/O time: 0.000781 sec
Total time: 0.048362 secs
I/O time: 0.000788 sec
Total time: 0.044538 secs
I/O time: 0.000863 sec
Total time: 0.0497582 secs
I/O time: 0.000869 sec
Total time: 0.044399 secs
I/O time: 0.000806 sec
Total time: 0.048337 secs
I/O time: 0.000768 sec
Total time: 0.0443618 secs
I/O time: 0.000784 sec
Total time: 0.047996 secs
I/O time: 0.000787 sec
Total time: 0.0448439 secs
I/O time: 0.001107 sec
Total time: 0.049104 secs
I/O time: 0.000770 sec
Total time: 0.0441971 secs
I/O time: 0.000780 sec
Total time: 0.0489569 secs
I/O time: 0.000789 sec
Total time: 0.0474629 secs
```

```
I/O time: 0.000889 sec
Total time: 0.0496821 secs
I/O time: 0.000790 sec
Total time: 0.0429571 secs
I/O time: 0.000912 sec
Total time: 0.0503609 secs
I/O time: 0.000777 sec
Total time: 0.047833 secs
I/O time: 0.000789 sec
Total time: 0.0483789 secs
I/O time: 0.000778 sec
Total time: 0.043772 secs
I/O time: 0.000791 sec
Total time: 0.0480478 secs
I/O time: 0.000784 sec
Total time: 0.0473752 secs
I/O time: 0.001329 sec
Total time: 0.049175 secs
I/O time: 0.000796 sec
Total time: 0.044662 secs
I/O time: 0.000916 sec
Total time: 0.049969 secs
I/O time: 0.000802 sec
Total time: 0.0457921 secs
I/O time: 0.000797 sec
Total time: 0.0554059 secs
I/O time: 0.000804 sec
Total time: 0.0453029 secs
I/O time: 0.000773 sec
Total time: 0.049032 secs
I/O time: 0.000926 sec
Total time: 0.0446489 secs
I/O time: 0.000790 sec
Total time: 0.0475879 secs
I/O time: 0.000878 sec
Total time: 0.053205 secs
I/O time: 0.000770 sec
Total time: 0.0479331 secs
I/O time: 0.000812 sec
Total time: 0.042774 secs
```





[37]:
```
if (len(runtimes_drr_rl) > 0):
    runtimes_drr_rl_avg = round(np.mean(runtimes_drr_rl))
    runtimes_drr_rl_std = round(np.std(runtimes_drr_rl))
else:
    runtimes_drr_rl_avg = -1;
    runtimes_drr_rl_std = 0;
```

[38]:
```
if (len(runtimes_drr_ap) > 0):
    runtimes_drr_ap_avg = round(np.mean(runtimes_drr_ap))
    runtimes_drr_ap_std = round(np.std(runtimes_drr_ap))
else:
```

```
    runtimes_drr_ap_avg = -1;
    runtimes_drr_ap_std = 0;
```

8.2 Comparison the analytic simulation with the ground truth data

8.2.1 Quantitative validation

Compute image metrics between the two simulated images:

1. zero-mean normalised cross-correlation (ZNCC), and
2. Structural Similarity Index (SSIM).

ZNCC can be expressed as a percentage, which eases the interpretation of the numerical values. SSIM is a number between 0 and 1. A good value of ZNCC is 100%, and SSIM 1.

Note than the mean absolute percentage error (MAPE), also known as mean absolute percentage deviation (MAPD), is not used due to 1) zero values in the ground truth, and 2) values are very smalls. Using the MAPE would lead to large errors for these reasons.

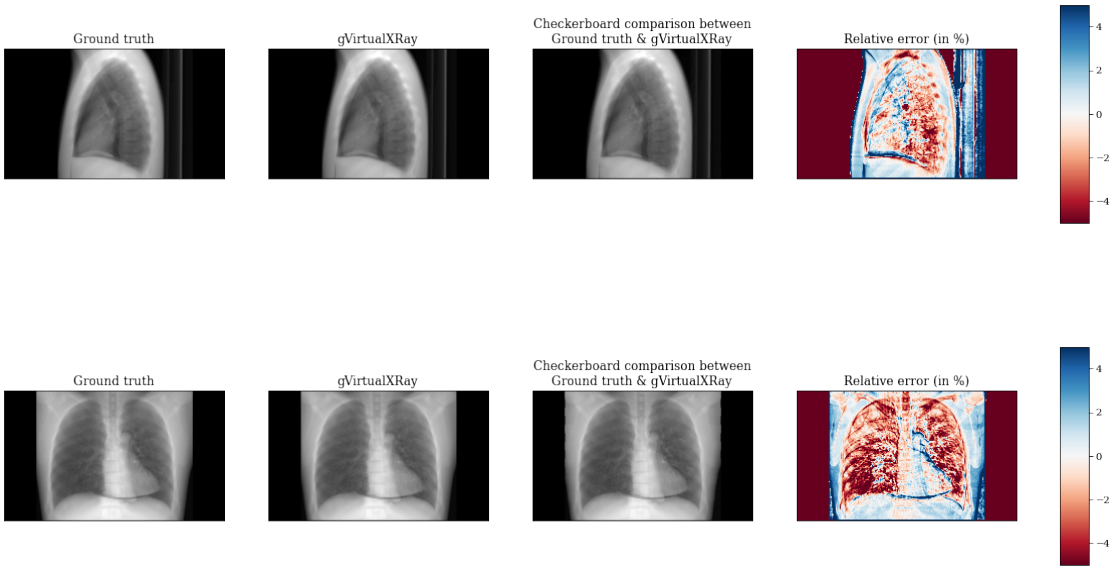
[39]:
```
def compare(ref_image, test_image):

    ZNCC = np.mean((ref_image - ref_image.mean()) / ref_image.std() *␣
↪(test_image - test_image.mean()) / test_image.std())
    print("ZNCC:", "{0:0.2f}".format(100 * ZNCC) + "%")

    offset1 = min(ref_image.min(), test_image.min())
    offset2 = 0.1 * (ref_image.max() - ref_image.min())
    MAPE = mape(ref_image.flatten() - offset1 + offset2, test_image.flatten() -␣
↪offset1 + offset2)
    print("MAPE:", "{0:0.2f}".format(100 * MAPE) + "%")

    SSIM = ssim(ref_image, test_image, data_range=ref_image.max() - ref_image.
↪min())
    print("SSIM:", "{0:0.2f}".format(SSIM))

    return ZNCC, MAPE, SSIM
```

Medical orientations with plastimatch.

[40]:
```
print('R-L:')
ref_proj = DRR_RL
test_proj = minus_log_proj_rl
ZNCC_DRR_RL, MAPE_DRR_RL, SSIM_DRR_RL = compare(ref_proj, test_proj)
fullCompareImages(ref_proj,
                  test_proj,
                  "gVirtualXRay",
                  "plots/lungman-compare-projs-plastimatch-rl",
                  False,
```

```
                    ref_proj.min(), ref_proj.max())
print('\nA-P:')

ref_proj = DRR_AP
test_proj = minus_log_proj_ap
ZNCC_DRR_AP, MAPE_DRR_AP, SSIM_DRR_AP = compare(ref_proj, test_proj)
fullCompareImages(ref_proj,
                  test_proj,
                  "gVirtualXRay",
                  "plots/lungman-compare-projs-plastimatch-ap",
                  False,
                  ref_proj.min(), ref_proj.max())
```

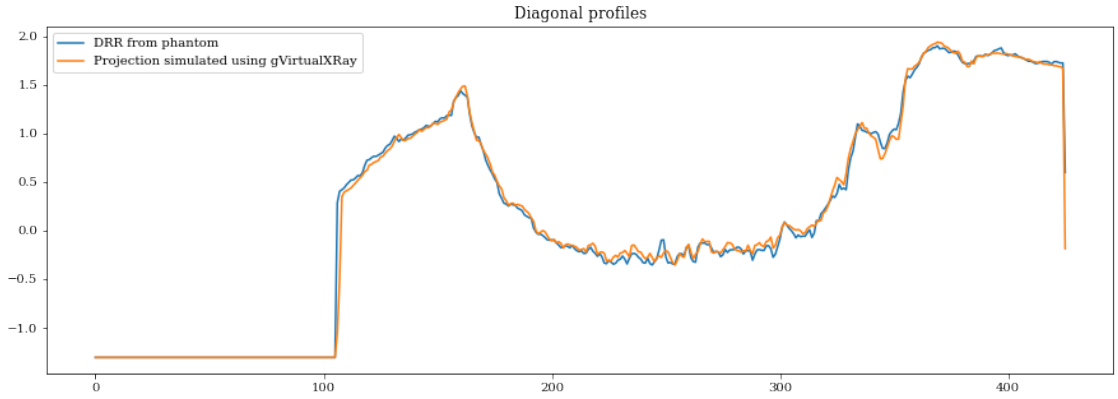
```
R-L:
ZNCC: 99.83%
MAPE: 1.92%
SSIM: 0.98

A-P:
ZNCC: 99.61%
MAPE: 1.84%
SSIM: 0.93
```



[41]:
```
ref_diag = np.diag(ref_proj)
test_diag = np.diag(test_proj)

plt.figure(figsize=(15, 5))
```

```
ax = plt.subplot(111)

ax.set_title("Diagonal profiles")

ax.plot(ref_diag, label="DRR from phantom")
ax.plot(test_diag, label="Projection simulated using gVirtualXRay")

ax.legend(loc='upper center', bbox_to_anchor=(0.5, 1.05),
          ncol=3, fancybox=True, shadow=True)

plt.legend()
```

[41]: <matplotlib.legend.Legend at 0x7f04bafaa4f0>



Print a row of the table for the paper

[42]:
```
print("Lungman AP view & Plastimatch DRR & " +
      "{0:0.2f}".format(100 * MAPE_DRR_AP) + "\\%    &    " +
      "{0:0.2f}".format(100 * ZNCC_DRR_AP) + "\\%    &    " +
      "{0:0.2f}".format(SSIM_DRR_AP) + "    &    $" +
      str(DRR_AP.shape[1]) + " \\times " + str(DRR_AP.shape[0]) + "$    &    " +
      str(number_of_triangles) + "    &    " + str(runtimes_drr_ap_avg) + " \\pm␣
 ↪" + str(runtimes_drr_ap_std) + "    & " +
      "$" + str(runtime_avg) + " \\pm " + str(runtime_std) + "$ \\\\")
```

```
Lungman AP view & Plastimatch DRR & 1.84\%    &    99.61\%    &    0.93    &
$725 \times 426$    &    19277756    &    416 \pm 4    & $37 \pm 5$ \\
```

[43]:
```
print("Lungman RL view & Plastimatch DRR & " +
      "{0:0.2f}".format(100 * MAPE_DRR_RL) + "\\%    &    " +
      "{0:0.2f}".format(100 * ZNCC_DRR_RL) + "\\%    &    " +
      "{0:0.2f}".format(SSIM_DRR_RL) + "    &    $" +
      str(DRR_AP.shape[1]) + " \\times " + str(DRR_AP.shape[0]) + "$    &    " +
```

```
    str(number_of_triangles) + "    &    " + str(runtimes_drr_rl_avg) + " \\pm␣
↪" + str(runtimes_drr_rl_std) + "    & " +
    "$" + str(runtime_avg) + " \\pm " + str(runtime_std) + "$ \\\\"
```

```
Lungman RL view & Plastimatch DRR & 1.92\%    &    99.83\%    &    0.98    &
$725 \times 426$    &    19277756    &    423 \pm 5    & $37 \pm 5$ \\
```