Question 1 (*8 marks*)

This question relates specifically to the following module learning outcomes: KU1, CS1, KS1, KS3 and PPS2.

- a.First, include a screenshot of the forum post you made in Part 1 of this topic (Exercise 1.1) describing a Messier object of your choice. Include just your initial post, not any subsequent discussion, and ensure that your name and the time and date of the post are visible (and clearly legible) in the screenshot.
  If you were unable to post in the forum at that time, you should have contacted your tutor to discuss alternative arrangements, most likely involving you emailing them the text that you would have used for your forum post. You may have agreed for your tutor to post this text to the forum on your behalf (anonymously or otherwise), and thus be able to capture a screenshot of that post instead.
  If you are unable to provide that screenshot for any reason, insert into your TMA submission a copy of the text of the email that you sent to your tutor – including the paragraph you wrote to describe your chosen Messier object. Be sure to include (either as a screenshot or copy-and-pasted text) the header showing the date and time that you sent the email.
  In the very unlikely scenario that you are unable to submit a screenshot or an email, you should write the paragraph describing your chosen object directly into your TMA submission. Remember that in all cases, your answer should be *between 50 and 150 words in length*.
  Second, include a second screenshot of the forum discussion comment that you added to your tutor group forum comparing your Messier object with another submission in the same forum, as described in (Exercise 1.1). Once again, if you were unable to post in the forum at that time, you should have made an alternative arrangement with your tutor. In the very unlikely scenario that you are unable to submit a screenshot or agreed alternative, you should write your discussion comment directly into your TMA submission.
  (**3 marks**)

- b.Download the TMA 03 galaxy classification images PDF, which is also available from the Resources section of the module website, and classify each **galaxy** as spiral, elliptical, lenticular or irregular. If it is spiral or elliptical, assign it to a subclass using the Hubble ‘tuning fork’ scheme, as you did in Part 2 Exercise 2.2.
  (**5 marks**)

Question 2 (*24 marks*)

This question relates specifically to the following module learning outcomes: KU1, CS1–CS3, KS2, KS3, PPS1 and PPS3.

This question is based on the Topic 3 activity and uses the JS9 tool.

Open the JS9 interface in a new browser tab or window and click on the link above the main window labelled Load TMA 03 files. This will to load an X-ray observation of a **supernova remnant** (SNR), which is located at a distance from us of 4.8 kpc. You may need to adjust the zoom and scale data limits slightly in order to produce a clear image of the whole **remnant**, as in Task 1 of the activity.

- a.Use the line tool and the Regions menu to make four measurements of the SNR diameter in different orientations, as in Task 2 of the activity. Provide a table of your four measurements, and an estimate of the uncertainty on each measurement.
  (*Hint*: the uncertainty can be estimated by examining how much longer or shorter you could make the line length without it looking obviously too long or short compared to the X-ray bright region. The size of the uncertainty will be the same, or similar, for your four measurements.)
  (**6 marks**)

- b.Calculate the mean (average) angular diameter of the remnant in units of arcseconds, and then calculate the diameter of the SNR in units of **parsec**.
  (**4 marks**)

- c.The **supernova** that produced this remnant is thought to have exploded in ~406 AD, while the Chandra X-ray observation you have used was made in 2006. The age of the supernova at the time of observation was therefore 1600 years.
  Calculate the speed of expansion of the remnant in units of km s^{-1}, assuming it has expanded at a constant speed throughout its lifetime. Is the remnant expanding faster or slower than the Tycho SNR that you studied in the activity?
  Based on the four diameter measurements you made in part a. of this question, and their uncertainties, comment on whether the SNR appears to have been expanding evenly in all directions.
  (**7 marks**)

- d.As mentioned in the activity, in reality the expansion speed of a SNR is not usually constant. For most of their lives their radius expands in proportion to age to the power of 0.4:

  where and are the radius of the SNR at ages and , respectively.
  Using this relationship and your measured size from the year 2006, reported in part b. of this question, estimate the **angular size** the remnant would have had in the year 1952.
  It was in 1952 that **radio** astronomers Jennison and Das Gupta first measured the size of an **extended** radio source, Cygnus A. The instrument they used – an interferometer – had a **spatial resolution** of 2 arcminutes. Based on the size you have calculated for this image, would the radio astronomers have been able to resolve the SNR in 1952 (assuming it was sufficiently bright)?
  (**7 marks**)