Singapore Astronomy Olympiad 2024

Data Analysis

Instructions

1. The data analysis portion of this Olympiad is worth a total of **20 marks**.
2. When asked to do so, check that you have **5** printed pages.
3. Write your answers and workings clearly on the answer sheets provided.
4. Submit all used answer sheets.
5. Fill in these details on each side of your answer sheet:
   - Year of competition
   - Your participant code
   - The page number – which should be continuous from 1 to N
   - The question number
6. Cross out all workings or answers you do not wish to be evaluated.
7. If you require assistance (e.g. to visit the restroom, enquire about an ambiguity or possible errata, etc.), please get the attention of the invigilators.

Competition Rules and Regulation

1. Only the use of scientific calculators is permitted. No graphing or programmable calculators are allowed.
2. Disruptive behaviour, cheating, collusion to cheat or any integrity-related offences are grounds for immediate disqualification.
3. You may opt to retain the question paper and constants sheet for personal use. Return all unused answer sheets to the Organising Team.

This page has been intentionally left blank

4 The Moving Cluster Method [20]

The moving cluster method is a means of determining the distance to a cluster of stars. For a cluster of stars which are travelling towards the same direction in space, their motions appear to converge towards a common point as seen by an observer on Earth. **Figure 1** illustrates this by showing how the proper motions of a cluster of stars can be plotted on a chart and extended along the direction of motion to converge at a common point. This common point is called the **convergent point**.

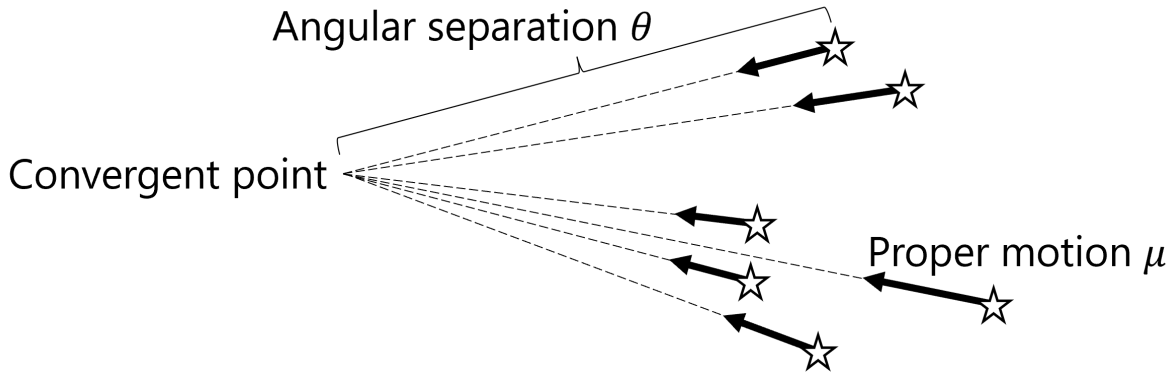

Figure 1: Convergent point of a cluster of stars, as seen on the celestial sphere by an observer on Earth.

The apparent angular separation θ between a star in a cluster, and the cluster's convergent point, is related to its distance d from the observer, as well as its proper motion μ and radial velocity v_r.

(a) Determine an expression relating the apparent angular separation θ between a star and its convergent point, to its transverse velocity $v_\perp$ and radial velocity v_r. **[1]**

(b) Hence, express the distance d of a star in terms of its apparent angular separation θ from its convergent point, its radial velocity v_r, and its proper motion μ. **[2]**

The Hyades is an open cluster that is situated relatively close to Earth. **Table 1** lists the observed properties of some bright stars in the sky around the Hyades cluster. Although these stars are located near each other on the celestial sphere, not all are members of the Hyades cluster.

(c) For each star in **Table 1**, decide whether it is likely to be a member of the Hyades cluster, and circle your answer in the second last column of the table. **Detach and submit Table 1 with your responses together with your answer script**. **[7.5]**

(d) For each of the stars that you have identified as members of the Hyades cluster, calculate its moving cluster distance d in parsecs using its given proper motion and radial velocity and write your answer in the last column of **Table 1**. **[7.5]**

(e) Calculate the weighted average distance d_{avg} in parsecs to the Hyades cluster members, using the masses of the individual stars as the weights. Hint: this is equivalent to

$$\frac{\sum M_i d_i}{\sum M_i} = \frac{M_1 d_1 + M_2 d_2 + \ldots + M_N d_N}{M_1 + M_2 + \ldots + M_N}$$

where M_i is the mass of the i^{th} star, d_i is the distance to the i^{th} star, and N is the total number of stars. **[1]**

(f) What is the likely identity of star 21 in **Table 1**? Write down its common name and Bayer designation. **[1]**

This page has been intentionally left blank

Table 1: List of 30 stars in the vicinity of the Hyades cluster.

Star	Right ascension (RA), α / °	Declination (DE), δ / °	Proper motion in RA, $\mu_\alpha \cos\delta$ / mas yr^{-1}	Proper motion in DE, μ_δ / mas yr^{-1}	Apparent V-band magnitude	Radial velocity, v_r / km s^{-1}	Angular separation from convergent point, θ / °	Mass, M / $M_\odot$	**Member of Hyades cluster?**	**Moving cluster distance,** d / pc
1	57.29055	24.05352	17.70	-44.18	3.62	8.5	42.63	4.74	**YES / NO**	
2	60.17009	12.49038	-8.02	-14.42	3.41	17.8	37.63	7.18	**YES / NO**	
3	60.78907	5.98931	4.72	-3.78	3.91	-3.6	36.89	2.25	**YES / NO**	
4	61.17357	22.08207	90.53	-59.47	4.36	9.5	38.63	1.99	**YES / NO**	
5	63.48496	9.26390	-10.31	-30.01	4.84	-7.7	34.18	2.84	**YES / NO**	
6	63.88352	8.89241	19.46	-22.11	4.27	16.3	33.78	6.70	**YES / NO**	
7	64.31536	20.57874	-39.41	-60.79	4.93	15.0	35.38	1.90	**YES / NO**	
8	64.94806	15.62770	115.46	-23.42	3.65	39.3	33.51	2.60	**YES / NO**	
9	65.73345	17.54258	106.56	-29.18	3.77	39.7	33.22	2.60	**YES / NO**	
10	66.02372	17.44421	108.16	-34.66	4.80	39.2	32.93	2.07	**YES / NO**	
11	66.34208	22.29398	105.10	-45.04	4.21	38.6	34.21	2.34	**YES / NO**	
12	66.37216	17.92799	107.60	-34.54	4.30	38.7	32.74	2.28	**YES / NO**	
13	66.57665	22.81369	108.81	-46.80	4.28	35.6	34.21	2.28	**YES / NO**	
14	66.58613	15.61835	114.31	-32.19	4.48	40.8	31.96	2.13	**YES / NO**	
15	66.65157	14.71386	-9.52	-31.44	4.69	31.3	31.71	3.94	**YES / NO**	
16	67.14347	15.96222	104.97	-15.14	3.84	40.2	31.52	2.50	**YES / NO**	
17	67.15389	19.18052	106.19	-37.84	3.53	39.4	32.41	2.60	**YES / NO**	
18	67.16531	15.87095	108.42	-26.74	3.40	38.9	31.48	2.60	**YES / NO**	
19	67.63987	16.19408	104.56	-25.90	4.78	41.0	31.11	2.08	**YES / NO**	
20	68.46190	14.84449	103.20	-26.48	4.65	37.7	30.03	2.11	**YES / NO**	
21	68.98000	16.50976	63.45	-188.94	0.87	54.4	29.95	1.16	**YES / NO**	
22	69.53917	12.51087	102.40	-15.78	4.27	44.7	28.56	2.26	**YES / NO**	
23	69.81855	15.91802	83.17	-20.97	4.67	35.6	29.02	2.27	**YES / NO**	
24	70.56126	22.95698	-2.89	-21.86	4.27	14.6	30.95	6.40	**YES / NO**	
25	72.45891	6.96125	464.06	11.21	3.19	22.5	25.27	1.24	**YES / NO**	
26	72.80153	5.60510	-2.21	0.85	3.68	23.3	24.98	10.95	**YES / NO**	
27	73.13318	14.25078	-0.05	-54.81	4.71	-8.4	25.50	0.90	**YES / NO**	
28	73.72377	10.15114	41.49	-128.73	4.64	18.2	24.17	1.97	**YES / NO**	
29	74.09300	13.51458	-74.88	-44.33	4.06	2.5	24.41	2.06	**YES / NO**	
30	75.77377	21.59006	68.88	-41.06	4.62	38.0	26.08	2.27	**YES / NO**	