Practical round. Basic grading criteria

αβ-7. Fireball.

7.1. Marking points I, II, III correctly. Marking and drawing the fireball trajectory correctly – 3 pts.

7.2. Getting longitude and latitude of Points A, B correctly. Getting distance with correct scaling over longitude and latitude – 2 pts.

7.3. Getting the right geometry. Final values of heights within 10 percent of error – 3 pts.

7.4. Getting the right geometry. Final values of the correct position within 10 percent of error – 2 pts.

α-8. Moon.

8.1. April (11 ± 1) – 2 pts, ± 2days – 1 pt.

8.2. Mrch (27 ± 1) – 2 pts, ± 2days – 1 pt.

8.3. Similar to the Figure in the answer sheet – 2 pts, ± 10 degrees – 1 pt.

8.4. Correct ratio ± 0.01 – 2 pts, ± 0.04 – 1 pts.

8.5. Similar to the figure in the solutions – 2 pts, radius less than 1 cm – 1 pts.

β-8. Clusters.

8.1. (2.0 point),
correct plot with main sequence line : 2.0 point,
plots without main sequence line : deduction of 0.1 point.

8.2. (2.0 point),
correct plot with different marks for each cluster : 2.0 point,
plots without identifying each cluster : deduction of 0.1 point.

8.3. (2.0 point),
E(B-V) ~ 0.06 ±0.02, get 2.0 point (±0.03, get 1.5 point; ±0.04, get 1.0 point; ±0.05, get 0.5 point).

8.4. (2.0 point),
Δm_V ~ -6.3 ±0.2 ➔ distance ~741pc
Correct method to get distance with wrong Δm_V values : deduction of 0.2 point

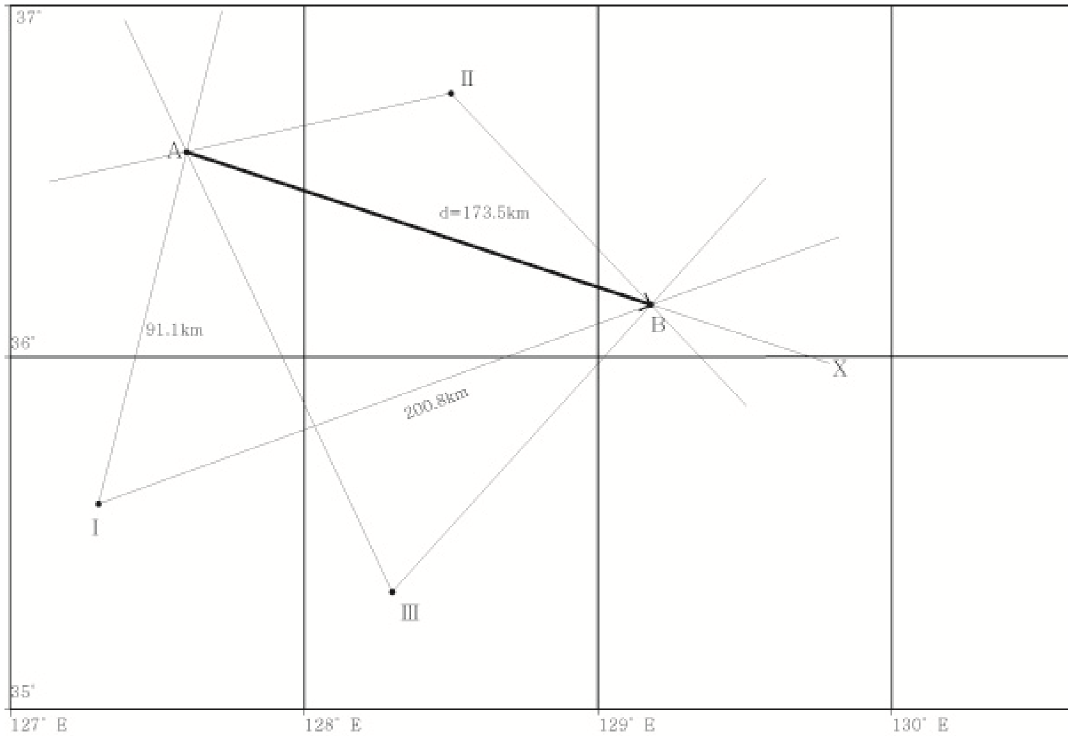
8.5. . (1.8 point),
only (B-V) value for main sequence turn off stars of each cluster (Hyades and NGC 2682) : get 0.9 point,
only absolute magnitude of it get 0.9.

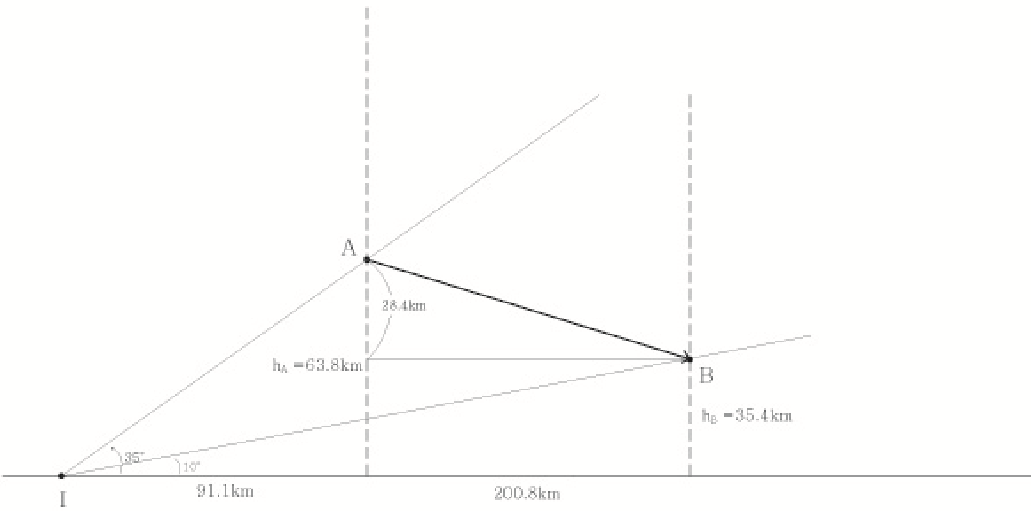
8.6. (0.2 point) NGC2682.

Practical round. Sketches for solutions

αβ-7. Fireball.

7.1. Observing points I, II and III are plotted as in the figure (point II is not correctly plotted below, but when plotted correctly on the gridded paper, the answer becomes clear). Then by drawing only using azimuthal angles, projected points A and B can be obtained, as intersecting points.





7.2. Read off from the grid, and coordinates (λ_A, φ_A, λ_B, φ_B) can be easily obtained as (127.60°E, 36.47°N) for point A, and (129.45°E, 36.10°N) for point B.

Then one should first convert the differences in angle into distance, and then use Pythagorean principle, such that

$$L = [\{(129.45-127.60) \times 110) \times (4.8/5.8)\}^2 + \{(36.47-36.10) \times 110\}^2]^{1/2},$$

where the conversion factor 4.8/5.8 for longitudinal distance per one degree longitude can be read off from the correctly scaled gridded paper or using ~sin(90°-36°), and one can use 110 km / (latitude degree). Then L = 173.5 km.

7.3. Once points I, A & B are correctly marked, the distance $\mathbf{I_A}$ and $\mathbf{I_B}$ can be calculated using Pythagorean principle just as in problem 2, which are 91.1 km and 200.8 km. And using altitudes observed from point I, one can get

$$\mathbf{h_A} = 91.1 \text{ km} \times \tan 35° = 63.8 \text{ km, and } \mathbf{h_B} = 200.8 \text{ km} \times \tan 10° = 35.4 \text{ km}.$$

7.4. If the fireball hits the surface, the full projected trajectory from point **A** to the hitting point (let's call it **C**), **AC**, is the multiple of the projected distance **AB** by a factor of 63.8/(63.8-35.4)=2.2465. The same multiplication factor can be used to get the trajectory on the longitude and latitude separately, such that

$$\lambda_C = 127.6 + 2.2465\ (129.45\text{-}127.6) = 131.76°$$
$$\varphi_C = 36.49 + 2.2465\ (36.11\text{-}36.49) = 35.64°$$

point	longitude λ	latitude φ	L (km)	h_A (km)	h_B (km)	You may find the meteorite at longitude λ_C	latitude φ_C
A	127.60° E	+36.49° N	173.5	63.8 km	35.4 km	131.76°E	35.64°N
B	129.45° E	+36.11° N					

α-8. Moon.

Date	Culmination of Moon	ΔT (min)	Date	Culmination of Moon	ΔT (min)	Date	Culmination of Moon	ΔT (min)
Mar 2	19 40	51	April 1	20 02	50	May 1	20 20	50
3	20 31	51	2	20 52	50	2	21 10	52
4	21 22	52	3	21 42	51	3	22 02	55
5	22 14	51	4	22 33	52	4	22 57	59
6	23 05	51	5	23 25	54	5	23 56	61
7	23 56	52	6	-		6	-	
8	-		7	0 19	57	7	0 57	65
9	0 48	53	8	1 16	57	8	2 01	62
10	1 41	55	9	2 16	60	9	3 03	61
11	2 36	56	10	3 17	61	10	4 04	56
12	3 32	59	11	4 19	62	11	5 00	52
13	4 31	59	12	5 19	60	12	5 52	48
14	5 30	59	13	6 15	56	13	6 40	46
15	6 29	57	14	7 08	53	14	7 26	43
16	7 26	54	15	7 57	49	15	8 09	43
17	8 20	51	16	8 43	46	16	8 52	43
18	9 11	48	17	9 28	45	17	9 35	43
19	9 59	46	18	10 10	43	18	10 18	42
20	10 45	44	19	10 53	46	19	11 02	46
21	11 29	43	20	11 36	43	20	11 48	48
22	12 12	43	21	12 19	45	21	12 36	48
23	12 55	43	22	13 04	47	22	13 24	50
24	13 38	44	23	13 51	48	23	14 14	50
25	14 22	46	24	14 39	48	24	15 03	49
26	15 08	46	25	15 27	50	25	15 52	48
27	15 54	49	26	16 17	50	26	16 40	47
28	16 43	49	27	17 06	49	27	17 27	47
29	17 32	50	28	17 55	48	28	18 14	48
30	18 22	50	29	18 43	48	29	19 02	49
31	19 12	50	30	19 31	49	30	19 51	

8.1. In the table above, we compute the difference in culmination times of two neighboring days. On average it is about 48 minutes, but differs every day due to the elliptical nature of the lunar orbit. Figure 1 shows the variation of culmination time for the three months. When the moon is at the perigee, the difference in culmination is the largest. Therefore, the moon is at the perigee on Mar 13, April 11, May 7. Therefore, the answer is 11.

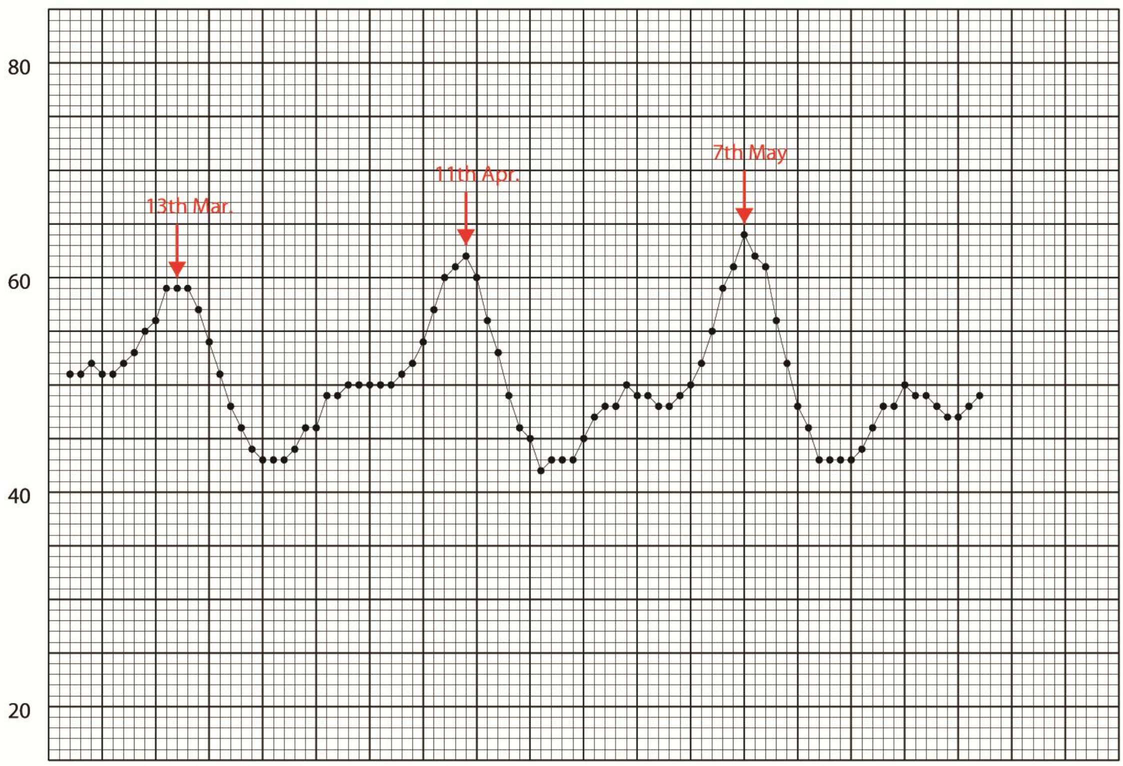
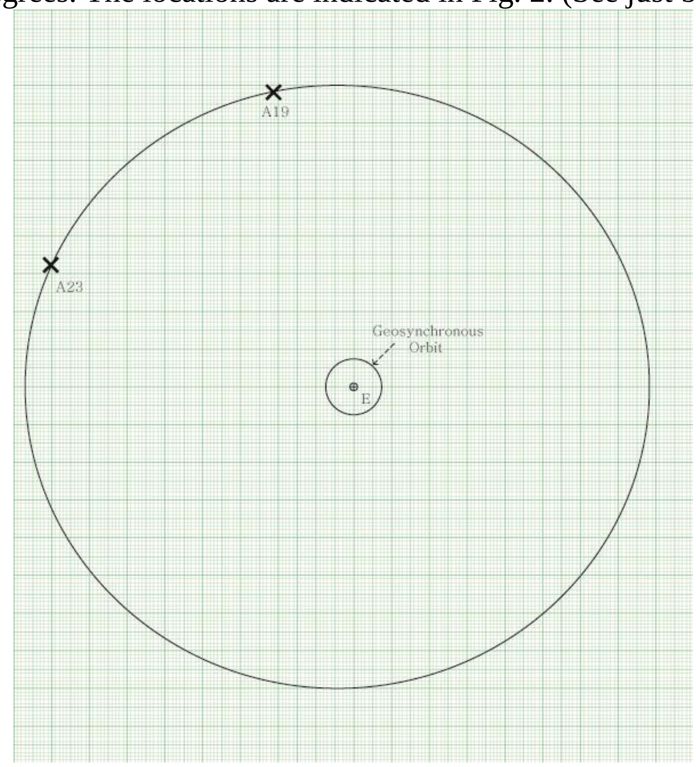


Fig 1. Culmination time difference in minutes.
On the dates marked by the red arrows the moon is at perigee.

8.2. 14 days after Mar 13 (or 14 days before April 11) the moon is located on the opposite side of the perigee. Therefore, the answer is Mar 27.

8.3. There are 8 days between April 11 and April 19, which correspond to 8/27.3 of the lunar orbital period. The angle from the perigee is 105.5 degrees. There are 12 days corresponding to 12/27.3 × 360=158.2 degrees. The locations are indicated in Fig. 2. (See just below.)

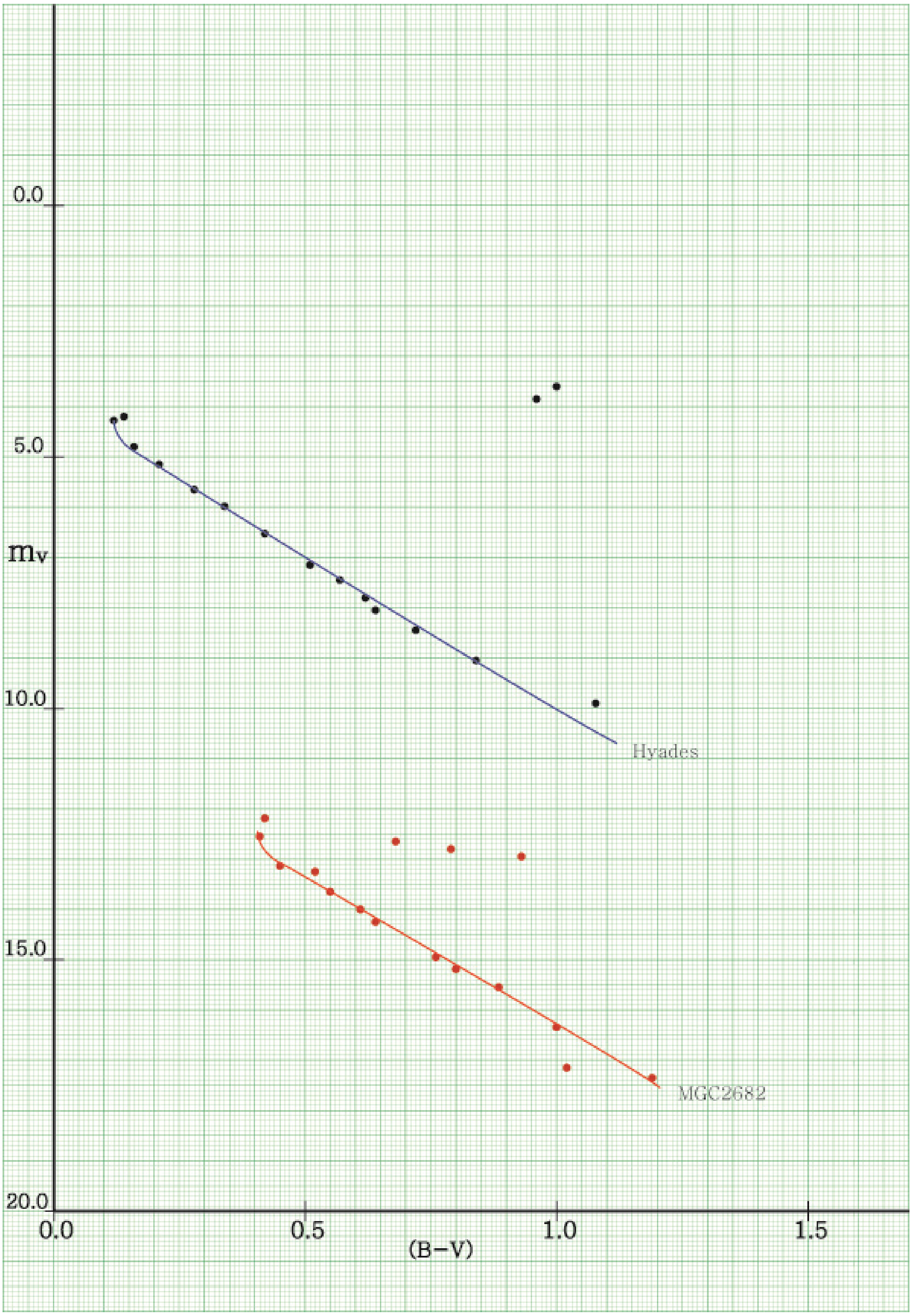


8.4. July 1 is 54 days after May 7th, where the Moon is at perigee. The Sun is near aphelion, whereas the Moon is near perigee. Therefore the sun's apparent angular diameter is 31'59" × 0.983 = 31'27". The real diameter of the moon is D = 3476.4 km. The distance is 384400" × (1 – 0.055) = 362900 km. Hence the apparent angular size is 3476/362900 × 180/3.14 × 60 = 32'54". Therefore, the moon appears 1.05 larger than the Sun.

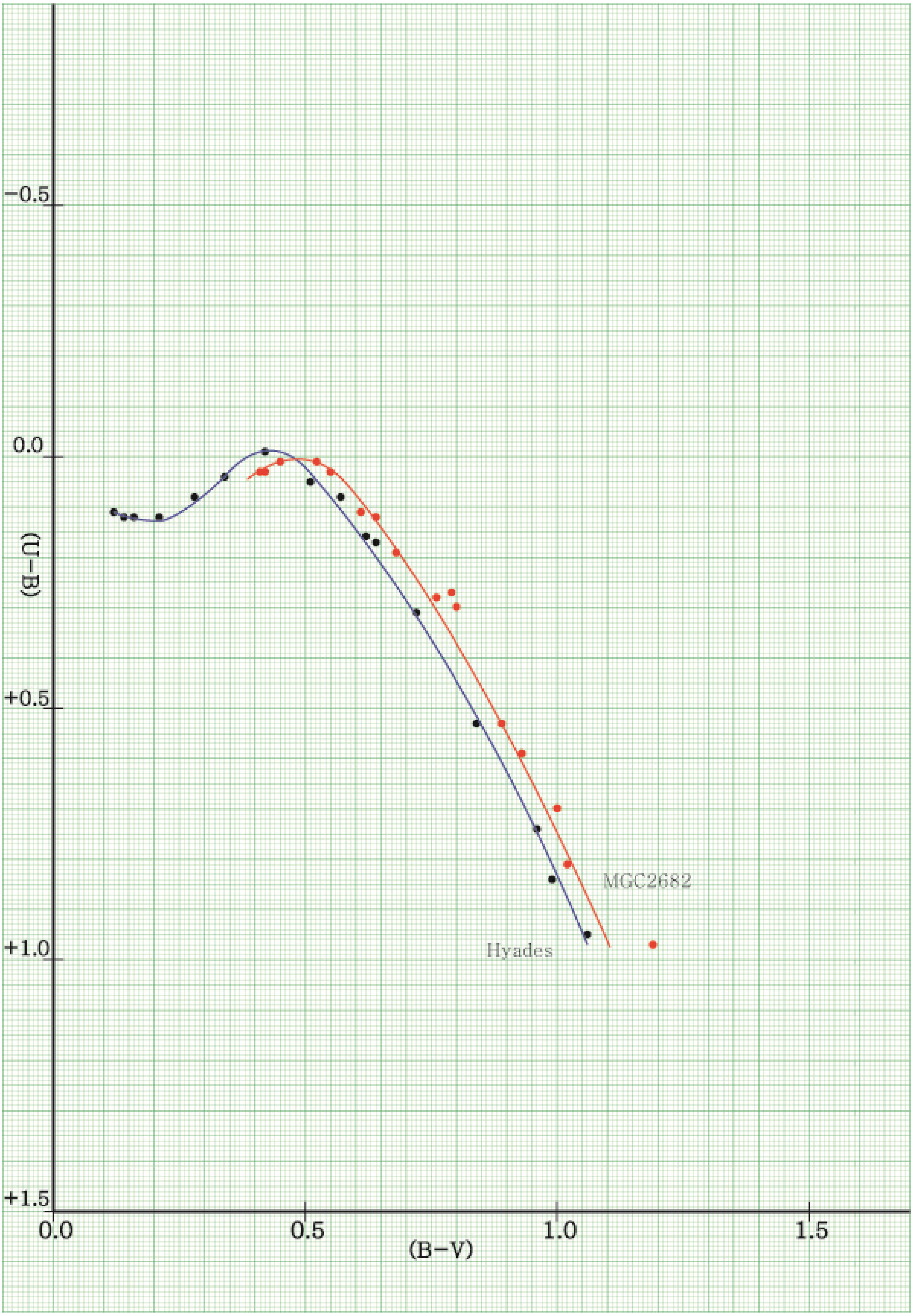
8.5. The approximate size of the geostationary orbit may be found using the Kepler's III law, with the additional fact that geostationary orbit has 27.3 times shorter period. The ratio or the orbital sizes is $27.3^{2/3}$, or approximately 9. The answer is shown in Fig. 2.

β-8. Clusters. All necessary data may be taken from tables and the Hertzsprung-Russell diagram.

8.1. Color-Magnitude Diagrams (blue dots and line for Hyades cluster, red dots and line for NGC2682).



8.2. Color-Color Diagram (blue dots and line for Hyades cluster, red dots and line for NGC6282):



8.3. On the color-color diagram (problem 8-2), the reddening line is E(U-B) / E(B-V) = 0.67. However, data points for two clusters are not sufficient to get such detailed reddening, we accept the difference (B-V) between two main-sequence lines on the color-color diagram as reddening E(B-V), which is E(B-V) ~ 0.06 (+- 0.02 acceptable).

8.4. On the color-magnitude diagrams in Problem 8-1, the magnitude difference Δm_V between the main sequence line of Hyades and the main sequence line of NGC 2686, which is Δm_V = -6.3 (±0.2 acceptable).

$$m_V(\text{Hyades}) - m_V(\text{NGC 2682}) = 5 \log 45 - 5\log \mathbf{d} - 3\cdot E(B\text{-}V),$$
$$-6.3 = 5 \log 45 - 5\log d - 0.18,$$
$$d = 741 \text{ pc } (660 \text{ pc} - 851 \text{ pc ; acceptable}).$$

8.5. Find the absolute magnitude and colour index (B-V) of the main sequence turn-off star in each cluster, approximately.

On the color-magnitude diagram of Hyades, MT (main sequence turn off point) is (B-V) ~ 0.12 (acceptable ±0.02) and m_V ~ 4.3 (acceptable ±0.2).

$$m_V - M_V = 5\cdot\log 45 - 5 - 0.18 \quad ==> \quad M_V = 0.75 \text{ (acceptable } \pm 0.2).$$

Ans: (B-V) = (B-V)o = 0.12, M_V = 0.75.

On the color-magnitude diagram of NGC2682, MT (main sequence turn off point) is (B-V) ~ 0.42 (±0.02 acceptable) and m_V = 12.6 (±0.2 acceptable).
Intrinsic color of the turn off star is (B-V)o = (B-V) - E(B-V) = 0.36 (acceptable : 0.32 - 0.40)

$$===> m_V - M_V = 5\cdot\log d - 5 + A \quad ==> \quad Mv = 3.41 \text{ (acceptable } 3.09 - 3.73).$$

Ans : (B-V) = 0.42, (B-V)o = 0.36 M_V = 3.41

8.6. NGC2682.