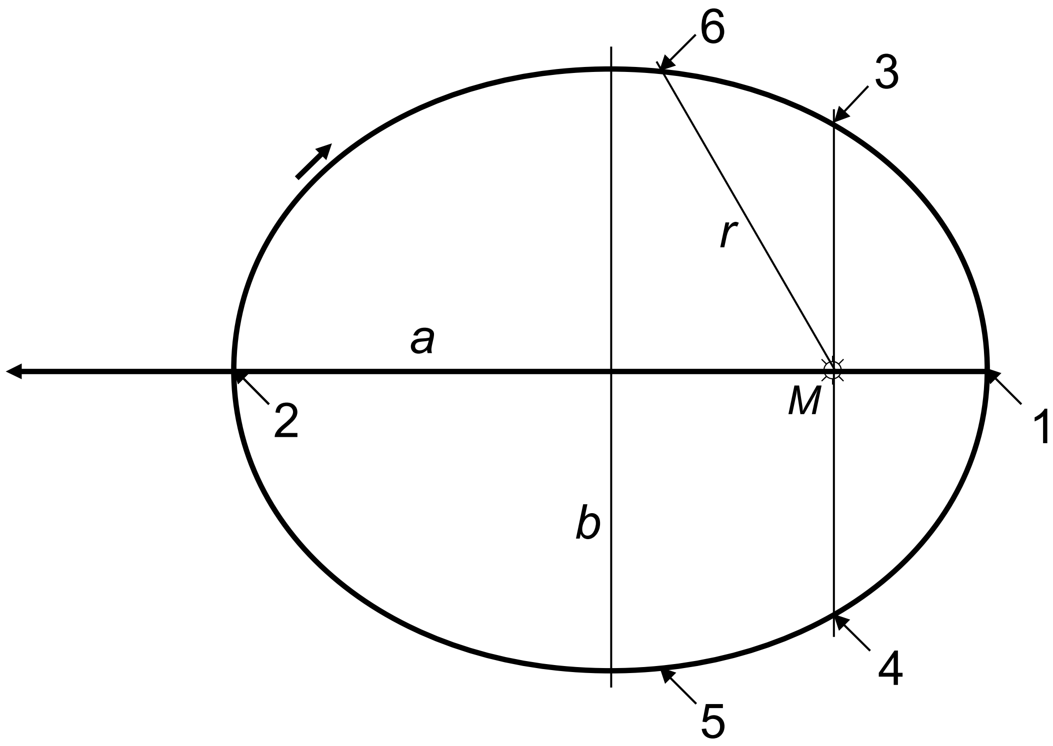
Question 1

20 elements to assess (7 constellations and 13 Messier Objects). For each full and correct answer **1 point**. For each partial or less accurate answer **0.5 point.**

Question 2



$v_{t\,\max}$ is at point 1 or 2, 2 points

$v_{t\,\min}$ is at point 2 or 1, 2 points

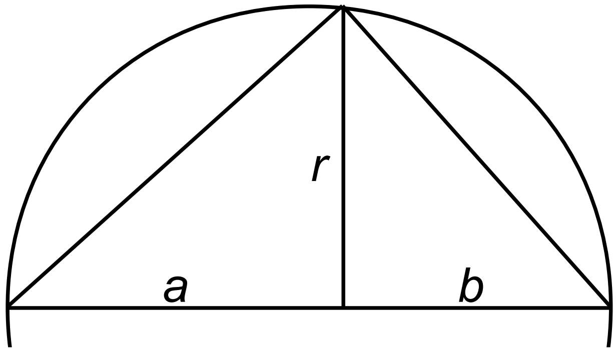
$v_{r\,\max}$ is at point 3, 5 points
(or at point 4 4 points)

$v_{r\,\min}$ is at point 4, 5 points
(or at point 3 4 points)

The momentary angular velocity of star *m* is jest than the mean angular velocity along the arc from point 5 through 2 to 6.

The value of the radius $r = \sqrt{ab}$ can be determined geometrically:

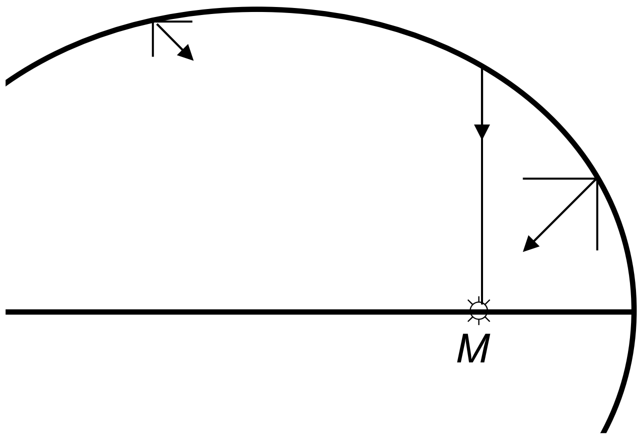
It is a right-angled triangle inscribed within a circle of radius $a+b$, of height r.



6 points

Reasoning:

The central acceleration due to the central gravitational force can be decomposed into radial and tangential coordinates. Only the radial component changes the radial velocity. The radial velocity has an extreme value when the acceleration changes sign.



3. Identifying telescope components

Look at the pictures of the telescope and match the names of the items with the corresponding letters. Write your answers in the table below:

Item name	Letter	Points
(example) Tripod	**M**	0
1. Counterweight	L	**0,5**
2. Right Ascension Setting Circle (R.A. Scale)	C	**0,5**
3. Declination Setting Circle (Declination Scale)	K	**0,5**
4. Right Ascension locking knob	B	**0,5**
5. Declination locking knob	J	**0,5**
6. Geographical latitude scale	A	**0,5**
7. Finder scope	F	**0,5**
8. Focuser tube	H	**0,5**
9. Focuser knob	G	**0,5**
10. Eyepiece	I	**0,5**
11. Declination Axis	XX	**0,5**
12. Right Ascension Axis (Polar Axis)	XY	**0,5**
13. Right Ascension slow motion adjustment	E	**0,5**
14. Declination flexible slow motion adjustment	D	**0,5**
15. 90° diagonal mirror	T	**0,5**
16. Azimuth adjustment knobs	P	**0,5**
17. Altitude adjustment screws	R	**0,5**
18. Lock screw	O	**0,5**
19. Spirit level bubble	W	**0,5**
20. Eyepiece reticle light – on/off switch & brightness control	U	**0,5**

Select and circle the correct answer for each of the questions below:

21. Mount type :
a. Fork *b*. Transit *c*. Dobsonian Alt-Azimuth *d*. **German Equatorial** **[1]**

22. Optical type :
a. Newtonian *b*. Cassegrain *c*. **Keplerian** *d*. Galilean **[1]**

23. Objective aperture :
a. 60 mm *b*. **80 mm** *c*. 90 mm *d*. 100 mm [**0.5]**

and objective lens focal length :
a. **400 mm** *b*. 500 mm *c*. 600 mm *d*. 800 mm **[0.5]**

24. Eyepiece focal length :
a. 4 mm *b*. 6 mm *c*. **12.5 mm** *d*. 25 mm **[1]**

25. Used for visual observations of the sky, the finder scope gives a picture which is :

a. normal *b*. **rotated by 180º** *c*. reflected in one axis *d*. rotated by 90º **[1]**

26. Used for visual observations **with** the diagonal mirror, the instrument gives a picture which is :

a. normal *b*. rotated by 180º *c*. **reflected in one axis** *d*. rotated by 90º [1]

Determine the following theoretical instrument parameters

27. Magnification : $M = f / f_{eyepiece}$ = 32x, or by measurement of image at eyepiece**[1 point]**
for 40x **[0.5 point]**

28. Focal ratio : 5 or f /5 or 1/5 (reverse convention) **[1]**

29. Resolution : r = 14/(D [cm]) = 1.75 arcsec or 1.22 lambda/D = 1.73 arcsec **[1]**
(in arcseconds)

30. Limiting magnitude: z = 5.5 + .5 log (D) + 2.5 log (M) for M = 32 gives z = 11.5 m
for M = 40 gives 11.8 mag
z = 7.5 + 5 log (D) gives 12 mag
z = 5 log (80/6) + 6 gives 11.6 mag

accept 11.5 mag to 12 mag **[1]**

Question 4

Outline:

During the secondary minimum, the star with the higher effective temperature is closer to the observer. We also know that it is larger. During the primary minimum we therefore have an annular eclipse – the cooler and smaller component is visible against the larger one, only obscuring it partially.

We use subscript:
0 – data concerning the sum of both components (outside eclipse),
1 – data concerning the hotter component,
2 – data concerning the cooler component,
g – data concerning the primary minimum,
R_1 and R_2 – radii of the stars, where $R_1 > R_2$,
T_1 and T_2 – effective temperatures of the stars, where $T_1 > T_2$,

Data from the plot:	looking for:
$m_1 - m_0 = 0{,}33$ mag.	$m_g = ?$
$d/D = 1/9$,	plot of the primary minimum

SInce both components are at the same distance from the observer, we can use the difference of the absolute magnitudes rather than the difference of the observered magnitudes:

$$m_g - m_1 = M_g - M_1 = -2{,}5\log\frac{L_g}{L_1},$$

where L_g and L_1 are the appropriate luminosities.

For star 1: $L_1 = \pi R_1^2 \cdot \sigma T_1^4$.

For the annulareclipse, the situation is more complicated:

$$L_g = \pi R_2^2 \cdot \sigma T_2^4 + \pi\left(R_1^2 - R_2^2\right)\cdot \sigma T_1^4 .$$

Rearranging:

$$m_g - m_1 = -2.5\log\left(\frac{R_2^2}{R_1^2}\left(\frac{T_2^4}{T_1^4} - 1\right) + 1\right).$$

m_g can be determined by finding the ratios: R_2/R_1 i T_2/T_1. The ratio of the radii is derived from the light curve, whereas the ratio of temperatures from photometric considerations.

If D is the duration of the primary minimum, while d is the duration of the 'flat bottom' during the eclipse, we get:

$$\frac{d}{D}=\frac{2\cdot(R_1-R_2)}{2\cdot(R_1+R_2)}=\frac{1-\frac{R_2}{R_1}}{1+\frac{R_2}{R_1}} \quad\Rightarrow\quad \frac{R_2}{R_1}=\frac{D-d}{D+d}=\frac{1-\frac{d}{D}}{1+\frac{d}{D}}=0{,}8 \quad .$$

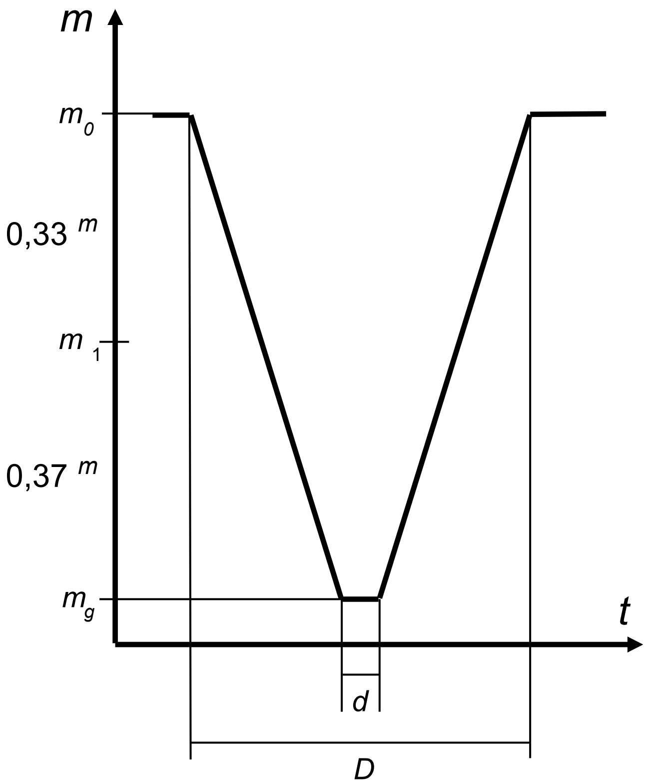
To obtain the ratio of temperatures, we need the observed brightness of star 2, or rather I_2/I_1 . Thus using Pogson's formula again:

$$m_1-m_0=2{,}5\log\frac{I_0}{I_1}=2{,}5\log\frac{I_1+I_2}{I_1}=2{,}5\log\left(1+\frac{I_2}{I_1}\right)$$

$$\Rightarrow \qquad \frac{I_2}{I_1}=10^{0{,}4(m_1-m_0)}-1,\ \text{ale}\ \frac{I_2}{I_1}=\frac{L_2}{L_1}=\left(\frac{R_2}{R_1}\right)^2\left(\frac{T_2}{T_1}\right)^4 \ \text{ and thus:}$$

$$\left(\frac{T_2}{T_1}\right)^4=\left(\frac{R_1}{R_2}\right)^2\left(10^{0{,}4(m_1-m_0)}-1\right) \quad\Rightarrow\quad \frac{T_2}{T_1}=0{,}86 \quad .$$

Subsituting numerical values we obtain $m_g - m_1 = 0{,}37^m$.



Points

$R_2/R_1 =$	5 points
$T_2/T_1 =$	5 points
$m_g - m_0 =$	5 points
drawing.	5 points

Question 5

Outline:

The inner edge of the movable ring, next to which the star will be visible, should be a clock face, and the inner edge of the card body should be a calendar scale..

The hour (and down to quarter-hour) scale should be marked in the direction of motion of the stars (i.e. anti-clockwise) – it should be in Sidereal Time units, i.e. with an error increasing to 4 minutes over the day.

4 points

The dates should also increase in the same direction (anticlockwise).

4 points

Both scales should be aligned, which should be aided by the mark at 0^h.

Practical notes: with the time 3^h15^m UT should be positioned at the lowest point (vertically) of the device, then the mark at 0^h00^m UT should show the current calendar date, 27 August.

4 points

As regards Sidereal Time,

the right ascension of β *UMi* from the atatched map is: $\alpha = 14^h 50^m$,
since this is at lower culmination, then Sidereal Time is: $\theta = 2^h 50^m$,

Practical notes: the time 2^h10^m ST should be at the lowest point of the device, as β *UMi* will always be at lower culmination at the same local sidereal time.

4 points

The mark at 0^h00^m ST should point to an analogous mark on the outer card (i.e. the ring should be "fixed" relative to the outer card. 4 points