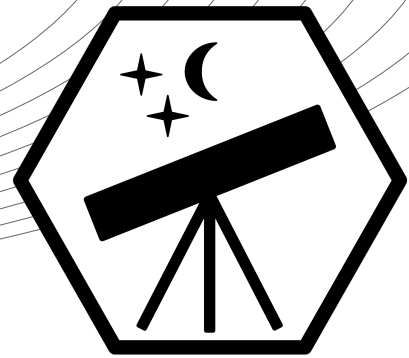


# International Astronomy and Astrophysics Competition Qualification Round 2023



## Problem A : The Classification of Galaxies (5 Points)

- (A1) irregular   (A2) elliptical   (A3) spiral   (A4) barred spiral  
(B1) spiral   (B2) irregular   (B3) barred spiral   (B4) elliptical  
(C1) NGC 300   (C2) NGC 2337   (C3) NGC 1365   (C4) Messier 110

## Problem B : The Speed of Light (5 Points)

$t = d/c$ : Mars: 12.4 minutes, Jupiter: 43.2 minutes, Pluto: 328.1 minutes

## Problem C : Elliptical Orbit (5 Points)

- (a)  $\varepsilon = \sqrt{1 - (b/a)^2} = 0.86$   
(b)  $P_1$ : perihelion,  $P_2$ : aphelion  
(c)  $x_1 = a(1 - \varepsilon)$  (2.3 AU),  $x_2 = a(1 + \varepsilon)$  (30.7 AU),  $x_3 = \sqrt{b^2 + (a\varepsilon)^2}$  (16.4 AU)  
 $\implies v_1$ : 26231 m/s,  $v_2$ : 1965 m/s,  $v_3$ : 7223 m/s

## Problem D : Distance between Stars (5 Points)

$d = 1/p$ :  $d_1$ : 9.09 pc (29.6 ly),  $d_2$ : 7.69 pc (25.1 ly)  $\implies d_{12} = \sqrt{(d_2 \sin(\varphi))^2 + (d_1 - d_2 \cos(\varphi))^2}$   
Result: 5.1 light-years

## Problem E : Dark Energy (5 Points)

phenomena in the large-scale universe causing accelerated expansion; evidences: redshift change with distance, missing global curvature (from cosmic microwave background), etc.