International Astronomy and Astrophysics Competition
Qualification Round 2022

Problem A : James Webb Space Telescope (5 Points)

(A) Primary mirror (B) Science instrument module (C) Optics subsystem
(D) Secondary mirror (E) Sunshield (F) Star trackers
(G) Spacecraft bus (H) Antenna (I) Solar array
(J) Stabilization flap

Problem B : Very Dense Earth (5 Points)

$$V = \frac{M}{\rho} = \frac{4}{3}\pi R^3 \quad \Rightarrow \quad D = 2R = 2\left(\frac{3M}{4\pi\rho}\right)^{1/3} = \left(\frac{6M}{\pi\rho}\right)^{1/3} = 283.6\,m$$

Problem C : Asteroid Field (5 Points)

Number of asteroid collisions: $N = \rho V = \rho \cdot \pi R^2 \cdot d$; momentum conservation:

$$Mv + Nmu \approx Mv = (M + Nm)w \;\Rightarrow\; w = \frac{Mv}{M + Nm} \;\Rightarrow\; \Delta v = v - w = v\left(1 - \frac{1}{1 + N\frac{m}{M}}\right)$$

Problem D : Position of the JWST (5 Points)

(a) To block the radiation of the Sun
(b) $\omega = 2\pi/365d = 0.017/d$
(c) $a = \frac{F}{m} = \omega^2(d_E + d) - G\frac{M}{(d_E+d)^2} = 2.57 \cdot 10^{-4}\,m/s = 22.2\,m/d$ (away from the Earth)
(d) The gravitational force of the Earth $F_{G,E} \rightarrow$ enables the stable Lagrange point L_2

Problem E : Infrared Radiation (5 Points)

$\rightarrow$ wavelength 1 mm to 700 nm; lower energy than red; $\rightarrow$ infrared mostly blocked by Earth's atmosphere; $\rightarrow$ cosmological redshift: capable of observing more distant objects
$\rightarrow$ observing through dust and clouds possible