4) $P_J = 11.86\ y$

a) Since given in years, can use $[P(\text{years})]^2 = [a(AUs)]^3$

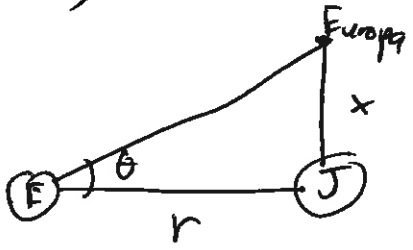
↑ $1\,AU = D_{ES}$

$a = P^{2/3} = 11.86^{2/3} = 5.2006\ AUs$

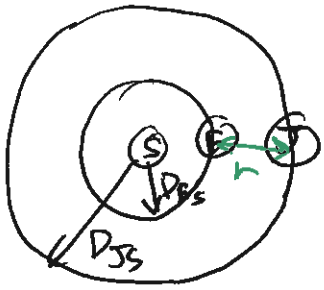
$= \boxed{7.78 \times 10^{11}\ m}$

b) Angular separation is like angular size,

$x = r\theta$ ↑ radians or: $\tan\theta = \frac{x}{r}$



But what is distance r?



$D_{ES} = 1.496 E11\ m$

$D_{JS} = 7.78015 E11\ m$ (above)

$r = D_{JS} - D_{ES} = 6.284 \times 10^{11}\ m$

then $\theta = 0.22\ \text{arcsec}$ 0.061°

$= 1.0666 \times$

then $x = r\theta = 1.0666E$

$= 6.702$

1 arcmin / 60 arcsec

70 km

4c) The book doesn't give a formula for this, but we can find our own from:

- Gravity, $F_g = GMm/r^2$ (1)
- Centripetal Force, $F_c = mv^2/r$ (2)
- velocity in an orbit is circumf / period.

$$v = \frac{2\pi r}{t} \quad (3)$$

M is the central mass, Jupiter, which we're trying to find

m is orbiting mass, Europa, trust me it'll cancel out.

r is orbital radius, $r = 6.711 \times 10^8 m$

t is orbital period, $t = 3.551$ days ⇒ ___ see?

$G = 6.67 \times 10^{-11}\ N m^2/kg^2$

Plan: Gravity causes centripetal motion, so (1) = (2), then plug in (3) for v.

$$\frac{G M m}{r^2} = \frac{m v^2}{r}$$

$$\frac{GM}{r} = v^2$$

This could also be found from $v_{orbit} = \sqrt{\frac{GM}{r}}$

$$\frac{GM}{r} = \left(\frac{2\pi r}{t}\right)^2$$

$$\frac{GM}{r} = \frac{4\pi^2 r^2}{t^2}$$

$$\frac{GM}{4\pi^2} t^2 = r^3$$

Oh look, $P^2 = a^3$! ☺

But we're trying to find M

$$M = \frac{4\pi^2 r^3}{G t^2}$$

Plug in values, above.

$$t = \frac{3.551 \text{ days}}{1} \left| \frac{24 \text{ hr}}{1 \text{ day}} \right| \frac{3600 \text{ sec}}{1 \text{ hr}} = 3.068 \text{E}5 \text{ sec}$$

$$M = 1.900 \times 10^{27} \text{ kg}$$

14.16

$m = 0.400\,kg \quad a_x = -2.70\,m/s^2 \;@\; x = 0.300\,m \quad T = ?$

Use the following equations

$a_x = \frac{-k}{m}x$, $\omega = \sqrt{\frac{k}{m}}$, $\omega = 2\pi f$, $f = \frac{1}{T}$

$-\frac{a_x}{x} = \frac{k}{m} \rightarrow \frac{m}{k} = \frac{x}{a}$ $\qquad f = \frac{\omega}{2\pi}$

$$T = \frac{1}{f} = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{-x}{a_x}}$$

$$= 2\pi\sqrt{\frac{0.300}{+2.70}}$$

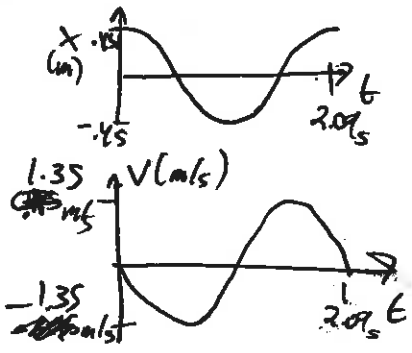
$$= 2\pi \cdot .\overline{3} = 2.09439$$

$$= \boxed{2.09\ s}$$

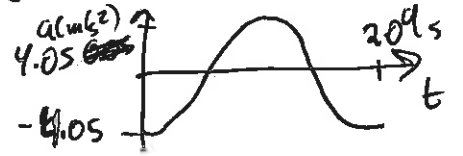
$$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{\alpha}{\alpha}} = \frac{\pi}{3}\ rad/s$$

$$x = A\cos(\omega t + \phi) \rightarrow x = (0.450m)\cos\left(\tfrac{\pi}{3}\ rad/s \cdot t\right)$$

$$v = -A\omega\sin(\omega t) \rightarrow v = -(1.35\,m/s)\sin\left(\tfrac{\pi}{3}\ rad/s \cdot t\right)$$



$$a = -A\omega^2\cos(\omega t) \rightarrow a = -(4.05\,m/s^2)\cos\left(\tfrac{\pi}{3}\ rad/s \cdot t\right)$$



14.15

$m_c = 42.5$ $\quad m_f = m_c + m_A = ?$

$T_c = 1.30_s$ $\quad T_f = 2.54_s$

$\omega = 2\pi f \rightarrow f = \frac{\omega}{2\pi}$

$T = \frac{1}{f} = \frac{2\pi}{f\omega} \rightarrow 2\pi = T\omega$

$\omega = \sqrt{\frac{k}{m}}$

$T_c \omega_c = T_f \omega_f$

$T_c \sqrt{\frac{k}{m_c}} = T_f \sqrt{\frac{k}{m_f}}$

$\frac{T_c^2}{m_c} = \frac{T_f^2}{m_f}$

$m_f = \left(\frac{T_f}{T_c}\right)^2 \cdot m_c$

$m_f = 162.24$

$m_A = 162.24 - 42.5$

$m_A = 119.74 = \boxed{120.\,kg}$

14.1

This problem is basically applying two formulae over & over:

$$f = 1/T \quad \text{or} \quad T = 1/f$$

$$\omega = 2\pi f \quad \text{or} \quad f = \omega/2\pi$$

green = given

	f (Hz)	ω (rad/s)	T (s)
a) Music Bb	466 Hz	2.93×10^{3} rad/s	2.15×10^{-3} s
b) Hearing High	2.00×10^{4} Hz	1.26×10^{5} rad/s	50 μs
c) Vision Red	~~7.5~~ $\times10^{14}$ Hz	2.7×10^{15} rad/s	2.3×10^{-15} s
Violet	4.3×10^{14} Hz	4.7×10^{15} rad/s	1.3×10^{-15} s
d) Ultrasound	5.0 MHz	3.1×10^{7} rad/s	2.0×10^{-7} s

14.49

$$T = 2\pi\sqrt{\frac{L}{g}}$$

$$L = 50.0\,cm = 0.500\,m$$

$$T = \frac{136\,s}{100} = 1.36\,s$$

$$T^2 = 4\pi^2\frac{L}{g}$$

$$g = \frac{4\pi^2}{T^2}L = \boxed{10.67\,m/s^2}$$