Question A (22 pts)

1	d	6	B
2	c	7	A
3	b	8	B
4	A	9	d
5	b	10	c

Question B (18 pts)

1	c	4	c	7 a	F	d	F	g	F	j	F
2	c	5	d	b	F	e	T	h	F	k	T
3	B	6	A	c	T	f	T	i	T	L	F

Question C (5 pts)

1	F	6	F	11	F
2	T	7	T	12	F
3	F	8	F	13	F
4	F	9	F	14	F
5	F	10	F	15	F

Question D (55 pts)

1	A	5	B	9	D
2	D	6	A	10	A
3	B	7	D	11	C
4	A	8	C	12	B

Working Out:

A3 $\frac{2.75}{2.3} = 1.195 = 19\%$

A4 $E = \frac{\sigma}{\varepsilon} = \frac{F \cdot L}{A \cdot \Delta L} = \frac{k \cdot \cancel{\Delta L} \cdot L}{A \cdot \cancel{\Delta L}} \longrightarrow k = \frac{E \cdot A}{L} \longrightarrow \frac{k_1}{k_2} = \frac{E_1}{E_2} = \frac{55.\bar{5}}{29.1\bar{6}} = 1.90 = 90\% \rightarrow \boxed{A}$

A5
$f_n = \frac{1}{2\pi} \cdot \sqrt{\frac{k}{m}}$ $\quad$ $E = 55.\bar{5}$ GPa $\quad$ $k = \frac{3 \cdot 4 \cdot 10^{-8} \cdot 55.5}{125} = 5.328 \times 10^{-8}$ $\quad$ $(5.333328 \times 10^{-5})$

$k = \frac{3EI}{L^3}$ $\quad$ $I = 4 \times 10^{-8}$ m^4

$V = A \cdot L = \pi r^2 \cdot L$ $\quad$ $L = 5$ m

$m = \rho V$ $\quad$ $r = 0.015$ m $\quad$ $V = \pi \cdot 0.015^2 \cdot 5 = 0.00353429$ m^3

$\rho = 2.75$ $\quad$ $m = 2.75V = 0.0097193$ kg

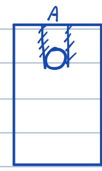
$f_{n_y} = \frac{1}{2\pi}\sqrt{\frac{5.328 \times 10^{-8}}{0.0097}} = 3.73 \times 10^{-4} \longrightarrow \boxed{B}$

A6 $\sigma_{nom} = \frac{F}{A^*} = \frac{100,000}{0.09 \times 0.006} = 1,85 \times 10^8 = 185$ MPa $\longrightarrow \boxed{B}$

A7 $K_t = \frac{\sigma_{Peak}}{\sigma_{nom}} \longrightarrow \sigma_p = 2.69 \times 1.66 \times 10^8 = 448$ MPa $< \sigma_{y_1} \longrightarrow \boxed{A}$

A8 $\longrightarrow$ $\hookrightarrow\ > \sigma_{y_2} \longrightarrow \boxed{B}$ (But $< \sigma_{ult_2}$)

A9 $\tau = \frac{F}{A} = \frac{100,000}{0.000175}$



$W = 0.1$ m

$e = 0.015$ m

$D = 0.010$ m

$t = 0.006$ m

$A = 2 \times e \cdot t = 0.00018$

$\tau = \frac{100,000}{0.00018} = 555$ MPa

should be bigger than 555, So 570 MPa $\rightarrow \boxed{d}$

A10 Tear-out $\rightarrow \boxed{C}$

B1 $\sigma_{circ} = \frac{\Delta p \cdot R}{t} = \frac{(88000 - 26500) \cdot \frac{5.9}{2}}{0.002} = 90{,}71$ MPa $\rightarrow \boxed{C}$

B2 $\sigma_{long} = \frac{1}{2} \cdot \sigma_{circ} = 45.35$ MPa $\rightarrow \boxed{C}$

B3 $\varepsilon = \frac{\sigma}{E} - \nu \frac{\sigma}{E} = \frac{\sigma}{E}(1 - \nu) = \frac{50}{60{,}000}(1 - 0.28) = 0.06\ \%$ $\rightarrow \boxed{B}$

B4 Isotropic $\rightarrow$ the same $\rightarrow \boxed{C}$

B5 N/m $\rightarrow \boxed{d}$

B6 $q = \frac{M_T}{2A} = \frac{1.8 \times 10^6}{2 \cdot A} = 32919{,}15$ $\quad A = \pi r^2 = \pi\, 2.95^2 = 27.33$ m^2

$\tau = \frac{q}{t} = 16459574.7 = 16.5$ MPa $\rightarrow \boxed{A}$

$\hookrightarrow 0.002$ m

B7 See reader for the theory

C See slides for the theory

D1 ① $\Delta V = I_{sp} \cdot g_0 \cdot \ln(\Lambda) \longrightarrow \Lambda = e^{\frac{\Delta V}{I_{sp} \cdot g_0}}$

② $t_b = \frac{I_{sp}}{\psi}\left(1 - \frac{1}{\Lambda}\right)$

$\hookrightarrow$ T-W ratio $= \frac{T}{M \cdot g_0}$

$$t_b = \frac{I_{sp} \cdot M \cdot g_0}{T}\left(1 - \frac{1}{e^{\frac{\Delta V}{I_{sp} \cdot g_0}}}\right)$$

$$t_b = \frac{2000 \cdot 300 \cdot 9.81}{0.1}\left(1 - \frac{1}{e^{\frac{2000}{2000 \cdot 9.81}}}\right)$$

$= 5704321.2$ [sec] $= 1584.53$ [h]

$= 66.02$ [days] $\rightarrow \boxed{A}$

D2 $\boxed{d}$ See slides for theory

D3 $F_g = G \cdot \frac{M \cdot m}{r^2} = 6.67 \times 10^{-11} \cdot \frac{10^{13}}{21002} = 0.0001512$ m/s² $= 0.151$ mm/s² $\rightarrow \boxed{B}$

$m = 1$ (1 kg for grav. acc.)

D4 Orbit time: $T = 2\pi\sqrt{\frac{a^3}{\mu}}$ $\quad a = \frac{\text{apo + peri + earth dia.}}{2} = \frac{(35800 + 200 + 12756) \times 10^3}{2} = 2.437 \times 10^7$

$\hookrightarrow = G \cdot M$

$\frac{1}{2}T = \pi\sqrt{\frac{a^3}{G \cdot M}} = 18931.8$ [sec] $= 5.25$ [h] $\rightarrow \boxed{A}$

Trivia: GTOs (almost?) always have an orbit time of 10.5 h.

D5 $V_{orbit} = R_E \sqrt{\frac{g_0}{R_E + h}} = 6.371 \times 10^6 \sqrt{\frac{9.81}{6.371 \times 10^6 + 200 \times 10^3}} = 7784.42 \ m/s$

Parabolic $\longrightarrow$ $e = 1$ $=$ Escape orbit $\quad r_{peri} = R_E + h$

$$V_{Esc} = \sqrt{\frac{2 \cdot \mu}{r_p}} = \sqrt{\frac{2 \cdot 3.986 \times 10^{14}}{6.578 \times 10^6}} = 11008.7 \ m/s$$

$$\Delta V = V_{Esc} - V_{orb} = 3224.3 \ m/s \longrightarrow \boxed{B}$$

D6 Eclipse Length:

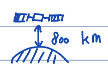
Earth-central half angle: $\sin(\lambda) = \frac{R_E}{a}$

$T_{eclipse} = \frac{2\lambda}{360°} \cdot 100\ \%$ (% of eclipse fraction)

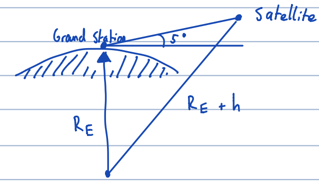
$T = \frac{2 \cdot \sin^{-1}\left(\frac{R_E}{a}\right)}{3.6} =$ $\quad a = R_e + h$

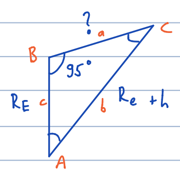
$T = 34.82\ \% \longrightarrow \boxed{A}$

D7 Min:



Max:





$\frac{\sin(A)}{a} = \frac{\sin(B)}{b} = \frac{\sin(C)}{c}$

$\frac{\sin(A)}{a} = \boxed{\frac{\sin(95)}{R_E + h} = \frac{\sin(C)}{R_E}} \longrightarrow C = \arcsin\left(\frac{R_E}{R_E + h} \sin(95)\right) = 62.27°$

we want to know this one

$180° = A + B + C \longrightarrow A = 180 - 62.27 - 95 = 22.73°$

$a = (R_E + h)\left(\frac{\sin(22.73)}{\sin(95)}\right) = 2783.85 \ km \longrightarrow \boxed{D}$

D8 $m \cdot c_p \cdot \frac{dT}{dt} = \sum \alpha \cdot A_{in} \cdot S - \varepsilon \cdot A_{out} \cdot \sigma \cdot T^4 + \cancel{Q_{int.}}\ 0$

Equi. $\rightarrow = 0$

$0 = 0.8 \cdot (0.01) \cdot 1367 - 0.2 \cdot (0.06) \cdot 5.67 \times 10^{-8} \cdot T^4$

fact sheet

$A_{in} = 10 \times 10 \ cm = 0.01 \ m^2$

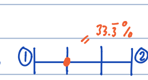
$A_{out} = 6 \times 10 \times 10 \ cm = 0.06 \ m^2$

Solve for T $\rightarrow$ $T = 356.06 \ k \longrightarrow \boxed{C}$

D9 $F_g = G \cdot \frac{M \cdot m}{r^2}$

$G \cdot \frac{M_1 \cancel{m}}{r_1^2} = G \cdot \frac{M_2 \cancel{m}}{r_2^2}$

$\frac{1}{r_1^2} = \frac{4}{r_2^2} \longrightarrow$ if $r_1 = 1$, $r_2 = 2 \Rightarrow$



$\longrightarrow \boxed{D}$

D10 $T = 20° = 293.15 \ k$

$Q = \sigma T^4 = 418.7 \ W/m^2$

$A \cdot Q = 4\pi R_E^2 \cdot Q = 2.14 \cdot 10^{17} \ W \longrightarrow \boxed{A}$

D 11

$$D = \frac{6000 \cdot d}{f} \sqrt{\frac{b}{P}}$$

distance

bitrate

↳ freq.

↳ power

$$64 = \frac{6000 \cdot 40 \cdot AU}{12 \times 10^9} \sqrt{\frac{1/6}{P}}$$

$\approx 1.495 \times 10^{11}$ m

$b = 10$ b/m $= \frac{1}{6}$ b/s

Solve for $P \rightarrow P = 364.25$ W $\longrightarrow \boxed{C}$

D 12

Costs: $400 \cdot M_{Dry} + 807 \cdot M_{Pay}$

$$\frac{M_P}{M_d} = \frac{1}{4} \longrightarrow M_{dry} = 4 \cdot M_{Pay}$$

$$\text{Costs} = M_{Pay}(1600 + 807)$$

$$500{,}000 = M \cdot 2407$$

$$M = 207.7 \text{ kg} \longrightarrow \boxed{B}$$