ENGINEERING TRIPOS PART IB

Paper 1 MECHANICS

Numerical Answers

Section A

1) (b) $\dot{\theta} = \sqrt{\dfrac{2aL}{k^2 + L^2}}$

(c) $\dfrac{ma\left(k^2 + 3L^2\right)}{k^2 + L^2}$, greater than

2) (a) $\ddot{\theta} = \dfrac{4g}{5L}$

(b) $\dfrac{\sqrt{2}}{5}mg$

(c) $\dfrac{8mgL}{135}$, $\dfrac{2}{3}L$ from top of slab

3) (a) $9mL^2$

(b) $\omega_{BC} = \dfrac{\omega}{2}$ clockwise, $\omega_{CD} = \omega$ anti-clockwise

(c) $T = 22mL^2\omega^2$

Section B

4) (a) (i) $a\cos\theta\,\mathbf{e}_1 + a\sin\theta\,\mathbf{k}$

(iii)
$$-a\left(\ddot{\theta}\sin\theta+\left(\dot{\theta}^2+\dot{\phi}^2\right)\cos\theta\right)\mathbf{e}_1$$
$$+a\left(\ddot{\phi}\cos\theta-2\dot{\theta}\dot{\phi}\sin\theta\right)\mathbf{e}_2$$
$$+a\left(\ddot{\theta}\cos\theta-\dot{\theta}^2\sin\theta\right)\mathbf{k}$$

(b) (ii) $ma^2\dot{\phi}\cos^2\theta$

5) (b) (i) $a\theta = b\phi$

(ii) $$V = mg\left[(a+b)\cos\theta-\frac{4b}{3\pi}\cos\left(1+\frac{a}{b}\right)\theta\right]$$

(iii) $$\frac{a}{b}>\frac{3\pi}{4}-1$$

6) Normal forces on wheels:

	Front left,	Front right,	Rear left,	Rear right
(a)	2250 N,	2250 N,	2750 N,	2750 N
(b)	2062.5 N,	1812.5 N,	3187.5 N,	2937.5 N
(c)	5000 N,	0,	5000 N,	0

ENGINEERING TRIPOS PART IB

Tuesday 5 June 2007 9.00 to 11.00

Paper 3; MATERIALS

Numerical Solutions

3 (d) $E \alpha \Delta T = 189$ MPa,
New fracture stress = 223 MPa

5 (c) Hoop stress = 40 MPa
Longitudinal stress = 20 MPa
Minimum yield stress = 100 MPa in the hoop direction
Minimum yield stress = 50 MPa in the longitudinal direction
(d) Need to increase the yield stress by at least a factor of 2 in the hoop direction

6 (c) Diffusion distance in 1 hour = 1.53 μm. Therefore, homogenisation is complete

ENGINEERING TRIPOS PART IB 2007

PAPER 4 – THERMOFLUID MECHANICS

ANSWERS

1 (a) 3.725 J/K

(b) (ii) $\alpha > 0.105$

2 (a) (ii) 0.834, 1161.3 kJ/kg (iii) 15.1 kJ/kg (iv) 0.361

3 (b) 330.4 K

(c) 6.15 bar

(d) 37.4 kJ per kg air

(e) 0.0118 kg H_2O per kg air

4 (a) Reynolds number and Strouhal number

(b) 60 m/s

(c) 2 Hz

(d) 0.926

(e) see crib

(f) see crib

5 (a) see crib

(b) $u = \frac{1}{2\beta}\frac{dp}{dx}\left(r + \frac{R_1 R_2}{r} - (R_1 + R_2)\right)$

(c) R_2/R_1

6 (a) $U_2 = 4U_1$

(b) $U_3 = 3U_1$

(c) $P_2 = P_1 + 9\rho U_1^2$

(d) $F = -4h(P_1 - P_3 + 12\rho U_1^2)$

(e) see crib

T.B. Nickels & J.B. Young

Answers to 1B paper 5 electrical

1 c 600 Ω, 18.6 kΩ
d V_E = -560 V V_{CC} = 15-20 V

2 b I_E = 18.7 mA, V_E = 2.81 V, V_C = 8.51 V
c I_E = 13.73 mA, V_E = 2.059 V
d V_C= 12.36 V
e gain = - 3.65, R_i = 6.5 kΩ

3b I_L = 13.12 kA, E = 27.003 kV, $\delta = 20.49^0$
c I = 17.155 kA
d I = 14.037 kA

4b delta; P = 3.97 kW, Q = 22.45 kVA
star P = 3.44 kW, Q = 2.58 kVA

Stot = 23.64 kW, cos ph 0.33

c V = 559 V
d V = 426.2 V

5d ws = 157 rad/s, s = 0.31 w = 108 rad/s T = 99.8 Nm

6d T = 0.065

7 L = 10^{-7} H/m, C = 4.10^{-11} F/m, a/b = 1.648, reflections = 5

2007 1B Paper 6

Answers

1 (b) GM = 9.54 dB, PM = 32.6 deg
Min at ≈ 0.9 rad/sec, Gain = 1.76
(d) GM = 12.6 dB, PM = 53.7 deg
Min at ≈ 2.1 rad/sec, Gain = 0.91

2 (a) $\bar{y}(s) = \frac{K(s)G(s)}{1+K(s)G(s)}\bar{r}(s) + \frac{G(s)}{1+K(s)G(s)}\bar{d}(s)$
(b) (i) $0.123\cos(7t+2.47)$
(ii) 0.5
(iii) $0.5+0.123\cos(7t+2.47)$

3 (b) $3 \leq k < \infty$
(c) 2.43
(d) $k_d = 2.12$

4 (c) SNR = 34.19 dB
(d) 77.8 kHz

5 -

6 (a) (ii) $\frac{\pi}{j}[\delta(\omega-\omega_o)-\delta(\omega+\omega_o)]e^{j\phi\omega/\omega_o}$
(b) (i) $f_s = 4$ kHz, $f_o = 1,5,9,13,\ldots$ kHz

Numerical solutions, IB Paper 7, 2007

1. (a) $\frac{\pi}{2}(\mathrm{e}^{-a^2} - \mathrm{e}^{-b^2})$
   (b) $\frac{\pi}{2}(\mathrm{e}^{-a^2} - \mathrm{e}^{-b^2})$
   (c) $\mathrm{e}^{-r^2}\hat{\mathbf{e}}_z$
   (d) -

2. (a) -
   (b) $64D/3$
   (c) $2D(2 - x^2 - y^2)$
   (d) $64D/3$

3. (a) -
   (b) -
   (c) $k = n(n+1)$

4. (a) $a = 2$
   (b) -
   (c) $x = 1/9$, $y = 8/3$
   (d) -

5. (a) np
   (b) -
   (c) $p^3(n^2 - n) + p^2 n$
   (d) pn

6. (a) $(\lambda/(s+k))^k$
   (b) -
   (c) k/λ, k/λ^2

Answers

Q3: b) i) N=2 for stiff clay and N=8.5 for soft clay
ii) σ_T = 175 kPa

Q4: b) FoS against sliding = 1.21
d) FoS against sliding = 0.92

Q5: a) Sagging Moment = 281 kNm Hogging Moment = 500 kNm
c) Steel area for sagging = 1703 mm^2 Steel area for hogging = 3208 mm^2
d) Spacing of Shear reinforcement = 345 mm

Part IB 2007 Paper 8 Selected Topics
Section C – Mechanics Materials and Design

Answers:

6. (c) $4/9\rho V^2 A$

7 (b)

σmin	σmax	$\Delta\sigma$	σ_m
-10	60	70	25
10	20	10	15
6	50	44	28

All stresses in MPa

(c) 0.49 years (clearly too short – need to redesign)

Numerical answers for Part IB 2007
Paper 8 Section D (Aerothermal Engineering)

9. (a) 42100 feet (c) 246, 0.0159 kg/passenger-km
10. (c) 52.0 kN, 0.907
11. (b) 82.0 %, 17.5 kg/s (c) 1.91 m (d) 485 kJ/kg, 6 (e) 14.7, 84.6 %

The above results are presented with an accuracy of 3 significant figures.

Numerical answers for Part IB 2007
Paper 8 Section E (Electrical Engineering)

Q 13

(a) 2×10^{21} m-3

(b) 10^{6} V/m
2×10^{-6} m

(c) 1.28 mA

(d) 1.51 V

Q14

(a) 2.82 $\text{ohm}^{-1}\ \text{m}^{-1}$

(b) 7.1×10^{-3} eV

(c) 1.76×10^{-7} m

(d) 3.5×10^{-12} s

Paper 8 Section G Engineering for the Life Sciences 2006/7 Crib

Question 20
(a) (i) 7/8
(c)(i) $N_A \propto m^{4/3}$