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Precandidacy Exam: Report

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1. First-order heading

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Abstract must not spill onto p.2

Figure 1: Trapped-mode wavenumbers, kd, plotted against a/d for three ellipses:
——, $b/a = 1$; $\cdots\cdots$, $b/a = 1.5$.

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1.1. *Second-order Heading*

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1.1.1. *Third-order Heading*

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2. Figures and Tables

2.1. *Figures*

Each figure should be accompanied by a single caption, to appear beneath, and must be cited in the text. Figures should appear in the order in which they are first mentioned in the text. For example see figures 1 and 2.

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Figure 2: The features of the four possible modes corresponding to (*a*) periodic and (*b*) half-periodic solutions.

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2.2. *Tables*

Tables, however small, must be numbered sequentially in the order in which they are mentioned in the text. Words *table 1, table 2* should be lower case throughout. See table 1 for an example.

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a/d	$M=4$	$M=8$	Callan *et al.*
0.1	1.56905	1.56	1.56904
0.3	1.50484	1.504	1.50484
0.55	1.39128	1.391	1.39131
0.7	1.32281	10.322	1.32288
0.913	1.34479	100.351	1.35185

Table 1: Values of kd at which trapped modes occur when $\rho(\theta) = a$.

3. Notation and style

Generally any queries concerning notation and journal style can be answered by viewing recent pages in the Journal. However, the following guide provides the key points to note. It is expected that Journal style and mathematical notation will be followed, and authors should take care to define all variables or entities upon first use. Also note that footnotes are not normally accepted. Abbreviations must be defined at first use, glossaries or lists/tables of abbreviations are not permitted.

3.1. *Mathematical notation*

3.1.1. *Setting variables, functions, vectors, matrices etc*

- **Italic font** should be used for denoting variables, with multiple-letter symbols avoided except in the case of dimensionless numbers such as *Re*, *Pr* and *Pe* (Reynolds, Prandtl, and Péclet numbers respectively, which are defined as `\Rey`, `\Pran` and `\Pen` in the template).

- **Upright Roman font** (or upright Greek where appropriate) should be used for:

  (i) (vI) label, e.g. T. t (transpose)

  (ii) Fixed operators: sin, log, d, Δ, exp etc.

  (iii) Constants: i ($\sqrt{-1}$), π (defined as `\upi`),e etc.

  (iv) Special Functions: Ai, Bi (Airy functions, defined as `\Ai` and `\Bi`), Re (real part, defined as `\Real`), Im (imaginary part, defined as `\Imag`), etc.

  (v) Physical units: cm, s, etc.

  (vi) Abbreviations: c.c. (complex conjugate), h.o.t. (higher-order terms), DNS, etc.

- **Bold italic font** (or bold sloping Greek) should be used for vectors (with the centred dot for a scalar product also in bold): $\boldsymbol{i} \boldsymbol{\cdot} \boldsymbol{j}$

- **Bold sloping sans serif font**, defined by the `\mathsfbi` macro, should be used for tensors and matrices: $\boldsymbol{\mathsf{D}}$

- **Calligraphic font** (for example $\mathcal{G}$, $\mathcal{R}$) can be used as an alternative to italic when the same letter denotes a different quantity use `\mathcal` in LaTeX)

3.1.2. *Other symbols*

Large numbers that are not scientific powers should not include commas, but should use a non-breaking space, and use the form 1600 or 16 000 or 160 000. Use O to denote 'of the order of', not the LaTeX $\mathcal{O}$.

The product symbol (×) should only be used to denote multiplication where an equation is broken over more than one line, to denote a cross product, or between numbers . The $\cdot$ symbol should not be used, except to denote a scalar product of vectors specifically.

3.1.3. *Example Equations*

This section contains sample equations in the JFM style. Please refer to the LaTeX source file for examples of how to display such equations in your manuscript.

$$(\nabla^2 + k^2)G_s = (\nabla^2 + k^2)G_a = 0 \tag{3.1}$$

$$\boldsymbol{\nabla}\cdot\boldsymbol{v} = 0, \quad \nabla^2 P = \boldsymbol{\nabla}\cdot(\boldsymbol{v}\times\boldsymbol{w}). \tag{3.2}$$

$$G_s, G_a \sim 1/(2\pi)\ln r \quad \text{as} \quad r \equiv |P-Q| \rightarrow 0, \tag{3.3}$$

$$\left.\begin{array}{ll} \dfrac{\partial G_s}{\partial y} = 0 \quad \text{on} \quad y = 0, \\ G_a = 0 \quad \text{on} \quad y = 0, \end{array}\right\} \tag{3.4}$$

$$-\frac{1}{2\pi}\int_0^\infty \gamma^{-1}[exp(-k\gamma|y-\eta|) + exp(-k\gamma(2d-y-\eta))]\cos k(x-\xi)t\mathrm{d}t, \qquad 0<y, \quad \eta<d, \tag{3.5}$$

$$\gamma(t) = \left\{ \begin{array}{ll} -\mathrm{i}(1-t^2)^{1/2}, & t \leqslant 1 \\ (t^2-1)^{1/2}, & t>1. \end{array}\right. \tag{3.6}$$

$$-\frac{1}{2\pi}\int_0^\infty B(t)\frac{\cosh k\gamma(d-y)}{\gamma\sinh k\gamma d}\cos k(x-\xi)t\,\mathrm{d}t$$

$$G = -\frac{1}{4}\mathrm{i}(H_0(kr)+H_0(kr_1)) - \frac{1}{\pi}\int_0^\infty \frac{\mathrm{e}^{-k\gamma d}}{\gamma\sinh k\gamma d}\cosh k\gamma(d-y)\cosh k\gamma(d-\eta) \tag{3.7}$$

Note that when equations are included in definitions, it may be suitable to render them in line, rather than in the equation environment: $\boldsymbol{n}_q = (-y'(\theta), x'(\theta))/w(\theta)$. Now $G_a = \frac{1}{4}Y_0(kr) + \widetilde{G_a}$ where $r = \{[x(\theta)-x(\psi)]^2 + [y(\theta)-y(\psi)]^2\}^{1/2}$ and $\widetilde{G_a}$ is regular as $kr \rightarrow 0$. However, any fractions displayed like this, other than $\frac{1}{2}$ or $\frac{1}{4}$, must be written on the line, and not stacked (ie 1/3).

$$\begin{aligned} \frac{\partial}{\partial n_q}\left(\frac{1}{4}Y_0(kr)\right) &\sim \frac{1}{4\pi w^3(\theta)}[x''(\theta)y'(\theta) - y''(\theta)x'(\theta)] \\ &= \frac{1}{4\pi w^3(\theta)}[\rho'(\theta)\rho''(\theta) - \rho^2(\theta) - 2\rho'^2(\theta)] \quad \text{as} \quad kr \rightarrow 0. \end{aligned} \tag{3.8}$$

$$\frac{1}{2}\phi_i = \frac{\pi}{M}\sum_{j=1}^{M}\phi_j K_{ij}^a w_j, \qquad i = 1, \ldots, M, \tag{3.9}$$

where

$$K_{ij}^a = \begin{cases} \partial G_a(\theta_i, \theta_j)/\partial n_q, & i \neq j \\ \partial \widetilde{G_a}(\theta_i, \theta_i)/\partial n_q + [\rho_i'\rho_i'' - \rho_i^2 - 2\rho_i'^2]/4\pi w_i^3, & i = j. \end{cases} \tag{3.10}$$

$$\rho_l = \lim_{\zeta \to Z_l^-(x)} \rho(x, \zeta), \quad \rho_u = \lim_{\zeta \to Z_u^+(x)} \rho(x, \zeta) \tag{3.11a, b}$$

$$(\rho(x, \zeta), \phi_{\zeta\zeta}(x, \zeta)) = (\rho_0, N_0) \quad \text{for} \quad Z_l(x) < \zeta < Z_u(x). \tag{3.12}$$

$$\tau_{ij} = (\overline{\overline{u}_i\overline{u}_j} - \overline{u}_i\overline{u}_j) + (\overline{\overline{u}_i u_j^{SGS} + u_i^{SGS}\overline{u}_j}) + \overline{u_i^{SGS}u_j^{SGS}}, \tag{3.13a}$$

$$\tau_j^\theta = (\overline{\overline{u}_j\overline{\theta}} - \overline{u}_j\overline{\theta}) + (\overline{\overline{u}_j\theta^{SGS} + u_j^{SGS}\overline{\theta}}) + \overline{u_j^{SGS}\theta^{SGS}}. \tag{3.13b}$$

$$\boldsymbol{Q}_C = \begin{bmatrix} -\omega^{-2}V_w' & -(\alpha^t\omega)^{-1} & 0 & 0 & 0 \\ \dfrac{\beta}{\alpha\omega^2}V_w' & 0 & 0 & 0 & \mathrm{i}\omega^{-1} \\ \mathrm{i}\omega^{-1} & 0 & 0 & 0 & 0 \\ \mathrm{i}R_\delta^{-1}(\alpha^t + \omega^{-1}V_w'') & 0 & -(\mathrm{i}\alpha^t R_\delta)^{-1} & 0 & 0 \\ \dfrac{\mathrm{i}\beta}{\alpha\omega}R_\delta^{-1}V_w'' & 0 & 0 & 0 & 0 \\ (\mathrm{i}\alpha^t)^{-1}V_w' & (3R_\delta^{-1} + c^t(\mathrm{i}\alpha^t)^{-1}) & 0 & -(\alpha^t)^{-2}R_\delta^{-1} & 0 \end{bmatrix}. \tag{3.14}$$

$$\boldsymbol{\eta}^t = \hat{\boldsymbol{\eta}}^t \exp[\mathrm{i}(\alpha^t x_1^t - \omega t)], \tag{3.15}$$

where $\hat{\boldsymbol{\eta}}^t = \boldsymbol{b}\exp(\mathrm{i}\gamma x_3^t)$.

$$\mathrm{Det}[\rho\omega^2\delta_{ps} - C_{pqrs}^t k_q^t k_r^t] = 0, \tag{3.16}$$

$$\langle k_1^t, k_2^t, k_3^t\rangle = \langle\alpha^t, 0, \gamma\rangle \tag{3.17}$$

$$\boldsymbol{f}(\theta, \psi) = (g(\psi)\cos\theta, g(\psi)\sin\theta, f(\psi)). \tag{3.18}$$

$$f(\psi_1) = \frac{3b}{\pi[2(a + b\cos\psi_1)]^{3/2}}\int_0^{2\pi}\frac{(\sin\psi_1 - \sin\psi)(a + b\cos\psi)^{1/2}}{[1 - \cos(\psi_1 - \psi)](2 + \alpha)^{1/2}}\mathrm{d}x, \tag{3.19}$$

$$\begin{aligned} g(\psi_1) = {} & \frac{3}{\pi[2(a + b\cos\psi_1)]^{3/2}}\int_0^{2\pi}\left(\frac{a + b\cos\psi}{2 + \alpha}\right)^{1/2}\left\{f(\psi)[(\cos\psi_1 - b\beta_1)S + \beta_1 P]\right. \\ & \times\frac{\sin\psi_1 - \sin\psi}{1 - \cos(\psi_1 - \psi)} + g(\psi)\left[\left(2 + \alpha - \frac{(\sin\psi_1 - \sin\psi)^2}{1 - \cos(\psi - \psi_1)} - b^2\gamma\right)S\right. \\ & \left.\left. + \left(b^2\cos\psi_1\gamma - \frac{a}{b}\alpha\right)F(\frac{1}{2}\pi, \delta) - (2 + \alpha)\cos\psi_1 E(\frac{1}{2}\pi, \delta)\right]\right\}\mathrm{d}\psi, \end{aligned} \tag{3.20}$$

$$\alpha = \alpha(\psi, \psi_1) = \frac{b^2[1-\cos(\psi-\psi_1)]}{(a+b\cos\psi)(a+b\cos\psi_1)}, \quad \beta - \beta(\psi,\psi_1) = \frac{1-\cos(\psi-\psi_1)}{a+b\cos\psi}. \tag{3.21}$$

$$\left.\begin{aligned} H(0) &= \frac{\epsilon\overline{C}_v}{\tilde{v}_T^{1/2}(1-\beta)}, \quad H'(0) = -1 + \epsilon^{2/3}\overline{C}_u + \epsilon\hat{C}_u'; \\ H''(0) &= \frac{\epsilon u_*^2}{\tilde{v}_T^{1/2}u_P^2}, \quad H'(\infty) = 0. \end{aligned}\right\} \tag{3.22}$$

LEMMA 1. *Let $f(z)$ be a trial Batchelor (1971, pp. 231–232) function defined on* $[0,1]$. *Let Λ_1 denote the ground-state eigenvalue for $-\mathrm{d}^2g/\mathrm{d}z^2 = \Lambda g$, where g must satisfy $\pm\mathrm{d}g/\mathrm{d}z + \alpha g = 0$ at $z = 0, 1$ for some non-negative constant α. Then for any f that is not identically zero we have*

$$\frac{\alpha(f^2(0)+f^2(1)) + \displaystyle\int_0^1 \left(\frac{\mathrm{d}f}{\mathrm{d}z}\right)^2 \mathrm{d}z}{\displaystyle\int_0^1 f^2 \mathrm{d}z} \geqslant \Lambda_1 \geqslant \left(\frac{-\alpha + (\alpha^2 + 8\pi^2\alpha)^{1/2}}{4\pi}\right)^2. \tag{3.23}$$

COROLLARY 1. *Any non-zero trial function f which satisfies the boundary condition $f(0) = f(1) = 0$ always satisfies*

$$\int_0^1 \left(\frac{\mathrm{d}f}{\mathrm{d}z}\right)^2 \mathrm{d}z. \tag{3.24}$$

4. Citations and references

All papers included in the References section must be cited in the article, and vice versa. Citations should be included as, for example "It has been shown (Rogallo 1981) that..." (using the `\citep` command, part of the natbib package) "recent work by Dennis (1985)..." (using `\citet`). The natbib package can be used to generate citation variations, as shown below.

`\citet[pp. 2-4]{Hwang70}`:
Hwang et al (1970, pp. 2-4)
`\citep[p. 6]{Worster92}`:
(Worster 1992, p. 6)
`\citep[see][]{Koch83, Lee71, Linton92}`:
(see Koch 1983; Lee 1971; Linton and Evans 1992)
`\citep[see][p. 18]{Martin80}`:
(see Martin 1980(@, p. 18)
`\citep{Brownell04,Brownell07,Ursell50,Wijngaarden68,Miller91}`:
(Brownell 2004; Brownell and Su 2007; Ursell 1950; Wijngaarden 1968; Miller 1991)
(Briukhanovetal et al 1967)
Bouguet (2008)
(Josep and Saut 1990)

The References section can either be built from individual `\bibitem` commands, or can be built using BibTex. The BibTex files used to generate the references in this document can be found in the JFM LaTeX template files folder provided on the website here.

Where there are up to ten authors, all authors' names should be given in the reference list. Where there are more than ten authors, only the first name should appear, followed by *et al.*

Supplementary data. Supplementary material and movies are available at https://doi.org/10.1017/jfm.2019...

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Declaration of interests. A Competing Interests statement is now mandatory in the manuscript PDF. Please note that if there are no conflicts of interest, the declaration in your PDF should read as follows: **Declaration of Interests**. The authors report no conflict of interest.

Data availability statement. The data that support the findings of this study are openly available in [repository name] at http://doi.org/[doi], reference number [reference number]. See JFM's research transparency policy for more information

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Author contributions. Authors may include details of the contributions made by each author to the manuscript'

Appendix A.

In order not to disrupt the narrative flow, purely technical material may be included in the appendices. This material should corroborate or add to the main result and be essential for the understanding of the paper. It should be a small proportion of the paper and must not be longer than the paper itself.

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