Marker ___________________

Theory 1

Student ___________________

TOTAL ___________________

Subquestion		Statement	Points	Marker		Consensus	
				Statement	Subquestion	statement	Subquestion
A1	a	Correct streamlines (at least one)	0.1				
	b	$v = \kappa / r$	0.15		(0.25)		
A2	a	$\tan\,\alpha\ =\ \frac{\kappa^2}{gr^3}$ or equivalent ***	0.25				
	b	$z\ =\ z_0 - \frac{\kappa^2}{2gr^2}$ (if at A1b $v \sim \frac{1}{r}$ PEP applied)	0.25		(0.5)		
B1	a	Correct trajectories	0.15				
	b	$v_0 = \kappa / r_0$	0.1		(0.25)		
B2	a	All trajectories correct	0.15				
B3	a	Expression for vortex density $(u^2\sqrt{3}/2)^{-1}$ ***	0.2				
	b	$v\ =\frac{2\pi\kappa r}{u^2\sqrt{3}}$ (if B3a is incorrect PEP applied)	0.2		(0.4)		
B4	a	AB(t) = AB(0)	0.35				
B5	a	$z(r) = z_0 + \frac{2\pi^2\kappa^2 r^2}{3gu^4}$ (if at B3b $v \sim r$ PEP applied)	0.25				
C1	a	Correct direction of momentum $\odot$	0.15				
	b	$P\ =\ 2\pi\kappa\rho bd$	0.15		(0.3)		
C2	a	Integration limits are βa and b where $\beta \approx 1$ ***	0.2				
	b	Case 1: Analogy with a magnitude field is used ($U = \frac{LI^2}{2}$ and $L = \frac{\Phi}{I}$) Case 2: Energy is calculated as $W\ =\ \int F dr$ and $F = \frac{dP}{dt}$ ***	0.2				
	c	$U\ =\ 2\pi\kappa^2\rho d \log\frac{b}{a}$ ($\log\left(\frac{b}{\beta a}\right) -\ correct$)	0.3		(0.7)		
C3	a	The result of C1 used ***	0.3				
	b	Momentum change is parallel to Y axis	0.1				
	c	Correct direction of momentum change ⇧	0.15				
	d	$\Delta P\ =\ 2\pi\kappa\rho bd$ (correct if similar to C1b)	0.2		(0.75)		
D1	a	Trajectory is straight line parallel to Y axis	0.1		(0.5)		

	b	Correct direction of velocity (upwards)	0.2				
	c	$v = \dfrac{E\lvert\lambda\rvert}{2\pi\kappa\rho}$ (if at C3d $\Delta P \sim b$ PEP applied)	0.2				
D2	a	Trajectory is straight line parallel to Z axis	0.1				
	b	Correct direction of velocity (upwards)	0.15				
	c	$P(t) = P_0 + 2\pi E R_0 \lvert\lambda\rvert t$ ***	0.15				
	d	$P = 2\pi^2 \rho R^2 \kappa$ ***	0.15				
	e	$R = \sqrt{R_0^2 + \dfrac{ER_0\lvert\lambda\rvert t}{\pi\rho k}}$	0.05		(0.6)		
D3	a	$v \sim \dfrac{1 + log\, R/a}{R} \left(\approx \dfrac{log\, R/a}{R}\right)$	1				
	b	$v = \begin{bmatrix} \dfrac{k}{2\sqrt{R_0^2 + \frac{ER_0\lvert\lambda\rvert t}{\pi\rho k}}}\left(1 + \log\dfrac{\sqrt{R_0^2 + \frac{ER_0\lvert\lambda\rvert t}{\pi\rho k}}}{a}\right) \\ \dfrac{k}{2\sqrt{R_0^2 + \frac{ER_0\lvert\lambda\rvert t}{\pi\rho k}}}\left(1 + \log\dfrac{R_0}{a}\right) \\ \dfrac{k}{2\sqrt{R_0^2 + \frac{ER_0\lvert\lambda\rvert t}{\pi\rho k}}}\log\dfrac{\sqrt{R_0^2 + \frac{ER_0\lvert\lambda\rvert t}{\pi\rho k}}}{a} \\ \dfrac{k}{2\sqrt{R_0^2 + \frac{ER_0\lvert\lambda\rvert t}{\pi\rho k}}}\log\dfrac{R_0}{a} \end{bmatrix}$ (if at D2e $R = \sqrt{a + bt}$ PEP applied)	0.5		(1.5)		
D4	a	$v(t) = v^*$	0.25				
E1	a	Trajectory is plotted correctly	0.15				
	b	Correct direction of velocity (⇦)	0.1				
	c	$v = \kappa/2h_0$	0.25		(0.5)		
E2	a	Ideas of using superposition principle and technique of image charges ***	0.25				
	b	$v_0 = \dfrac{\kappa}{2\sqrt{2}h_0}$	0.5		(0.75)		
E3	a	The trajectory has correct curvature	0.3				
	b	Correct direction of initial velocity (⬂)	0.2		(0.5)		
E4	a	Using of energy conservation law (or equivalent)	0.5				
	b	$v_\infty = \dfrac{\kappa}{h_0\sqrt{2}}$ (0.5 points – arithmetical error)	1.0		(1.5)		
			Total				

PEP (Propagation Error Principle): incorrect answers with right dimension obtained from earlier wrong results are to be accepted in case of right course of solution. That principle applied only in indicated cases.

Trajectory with the wrong direction indicated is considered as incorrect.