(1) Let \( M \) be a compact set and define
\[
\omega(M) = \bigcap_{T>0} \bigcup_{t \geq T} \Phi_t(M).
\]
Show that \( \omega(M) \supseteq \bigcup_{x \in M} \omega(x) \) and find an example where the inclusion is strict.

(2) Consider \( u' = u^2 - vu^3, v' = 0 \).

(i) Draw a phase portrait.

(ii) Find the points for which the maximal positive time of existence is finite, \( t^+(u,v) < \infty \).

(iii) Show that \( t^+ \) is not a continuous function when considered in \( \mathbb{R}_+ \cap \infty \) with the usual topology of convergence to infinity.

(3) Consider the equation \( z' = z^2 \) on the Riemann sphere, \( z \in \mathbb{C} \).

(i) Perform the change of coordinates \( \zeta = 1/z \) and find the vector field at \( z = \infty \).

(ii) Find (explicitly) all solutions and plot a phase portrait.

(iii) Show that all solutions converge to the origin.

(iv) Show that the origin is not Lyapunov stable.

(4) Sketch the phase portrait (in particular all heteroclinic and homoclinic orbits) to \( x'' = -V'(x) \), with \( V(x) = x^6 - 0.03x^5 - 4x^4 + 4x^2 + 0.2x \),