Response to referee 1

1. 2D simulations capture the qualitative features associated with fluid-particle motion. This has been confirmed by our previous numerical investigations (see references listed in this paper). Our results are in qualitative agreement with the experimental results of Segré and Silberberg (1962). To our knowledge multiple equilibrium positions for heavy particles have not been observed experimentally.

   Our simulations successfully capture effects of the channel size and the curvature of the flow profile. The results can therefore be applied, qualitatively, to real-world 3D phenomena where these parameters are important. The results may not be directly applicable to situations with 3D flows between two very close vertical plane walls because the fluid velocity profile will be almost flat along the height of the channel. This will reduce the lift force on the particles.

2. Details of the accuracy of our numerical results are given by Hu (1996), Hu & Patankar (2000) and Hu, Patankar & Zhu (2000).

3. We have not observed multiple steady states for particles in viscoelastic fluids for the parameters in our simulations. It might occur at higher Reynolds numbers. Currently we are unable to perform such simulations due to convergence difficulties.

4. To our knowledge statements 1-3 in our conclusions are not explicitly mentioned in literature. In fact statement 2 is our own conclusion.

   The disagreement with Bretherton's formula, as stated in the manuscript, is probably because the domain size is not large enough. Bretherton's formula may not be accurate for the parameters considered in our simulations. It was not practical for us to perform simulations at smaller Reynolds numbers (than we have considered) since that would require even larger simulation domains to capture the 'outer region'.

   We propose a general data structure that could be used to develop models for lift-off. Specifically, we have developed a correlation for the critical condition of lift-off of particles in Newtonian fluids using this data.

   We have now explicitly mentioned that the results of Segré & Silberberg are experimental.

5. We have considered the suggestions for improvement and have made appropriate changes in the manuscript. In particular, we would like to thank this reviewer for pointing out the error in equation 17.

   The long particle model presents a simple model for the particle slip velocity. It shows that the particle lags the fluid; in agreement with our numerical results. It correctly predicts the qualitative effect of particle rotation on the slip velocity.

Response to referee 2

1. Our dynamic simulations have been performed with a maximum density difference of 1.4. The results of our simulations with fixed particle height (figures 11 and 22) can be applied to particles of varying densities.

   Our correlation for lift-off is applicable for a range of Reynolds number (0.5 to 200) and is not restricted to large values of R.

   The non-dimensional parameters of the problem are important. The dimensional values (e.g. d = 1cm) are mentioned because the simulations are performed using dimensional parameters. The range of non-dimensional parameters in our simulations is typical for many practical applications.

   2D simulations capture the qualitative features associated with fluid-particle motion. This has been confirmed by our previous numerical investigations (see references listed in this paper). Our results are in qualitative agreement with the experimental results of Segré and Silberberg (1962). To our knowledge multiple equilibrium positions for heavy particles have not been observed experimentally.

   Our simulations successfully capture effects of the channel size and the curvature of the flow profile. The results can therefore be applied, qualitatively, to real-world 3D phenomena where these parameters are important.

2. The results on unbounded domains are presented to emphasize the differences with particle motion in bounded domains. Specifically, a moving heavy particle in equilibrium under the balance of weight and lift in an unbounded linear shear flow must be propelled by an external agent to balance the drag. This is unlike the motion of finite size particles in bounded domains.

3. The particle positions are updated explicitly in our numerical simulations based on the values of velocities. This is stated in the manuscript.

4. We agree with the reviewer’s comments regarding Saffman’s and McLaughlin’s equations. We have already made similar comments in the manuscript.

5. The disagreement with Bretherton’s formula, as stated in the manuscript, is probably because the domain size is not large enough. Bretherton’s formula may not be accurate for the parameters considered in our simulations. It was not practical for us to perform simulations at smaller Reynolds numbers (than we have considered) since that would require even larger simulation domains to capture the ‘outer region’.

6. The long particle model presents a simple model for the particle slip velocity. It shows that the particle lags the fluid; in agreement with our numerical results. It correctly predicts the qualitative effect of particle rotation on the slip velocity. It is not used model the lift force.

7. We have considered other minor comments of this reviewer and have made appropriate changes in the manuscript. Figure 8 describes the long particle model and the dimensions (such as channel width = 2W) specified in this figure are not applicable to the computational domain.