Classical Mechanics - exercise sheet 8

This week's exercises address rotating frames and the centrifugal and Coriolis forces. Please submit your solutions through the Blackboard site by 3pm on **Friday 4th December**.

Reading

Read about rotating frames and centrifugal and Coriolis forces in your favourite textbook. e.g.

Fowles & Cassiday	*Analytical Mechanics* (7th ed.)	chapter 5
Chow	*Classical Mechanics* (2nd ed.)	chapter 10
French & Ebison	*Introduction to Classical Mechanics*	chapter 8
Kibble & Berkshire	*Classical Mechanics* (5th ed.)	chapter 5
Thornton & Marion	*Classical Dynamics* (5th ed.)	chapter 10

1 Apparent gravity & Coriolis force   (5 marks)

What is meant by the term 'apparent gravity' as seen by an observer in the rotating frame of the Earth?

How would the weight of a runner of mass 70 kg vary if s/he were to run, at the latitude of Southampton (51° north), at 10 m s^{-1} to the (a) north, (b) east, (c) south and (d) west?

2 Shanghai Tower   (5 marks)

The 154 storey Burj Khalifa is the world's tallest building: 828 m tall, it is in Dubai (UAE) at a latitude of 25° N. A body is dropped from the top of the building, and falls to the ground beneath.

a) Calculate the magnitude and direction of the deflection experienced by the body as a result of the Earth's rotation. [Neglect air resistance, wind etc., unrealistic though this assumption may be.]

b) Explain your result qualitatively from the point of view of an observer in an inertial frame, not rotating with the Earth, who simply sees the body following Newtonian dynamics subject to the Earth's gravity.

The lifts (elevators) in the 530 m Guangzhou CTF Finance Center (at a similar latitude) are the fastest in the world, capable of speeds of 21 m s^{-1}. By how much would a passenger be likely to move her/his head to remain 'upright' during the descent?

3 Travel by air   (5 marks)

The Airbus A380 is a 550-seat aeroplane with a fully-laden mass of 500 tonnes. Heading due North at its cruising altitude, it flies at a steady speed of 900 km h^{-1}, and passes near to Southampton (latitude 51° N).

a) What force in an East-West direction is required to maintain the aircraft's course along a line of constant longitude?

b) How in practice does the aircraft maintain its true southerly track?

4 River flow   (5 marks)

A river of width D flows northward with speed v. Show that the water is lower at the West bank than at the East bank by approximately

$$\frac{2D\omega v \sin \lambda}{g}$$

where ω is the angular velocity of the Earth and λ the latitude.

How would you measure this effect experimentally?