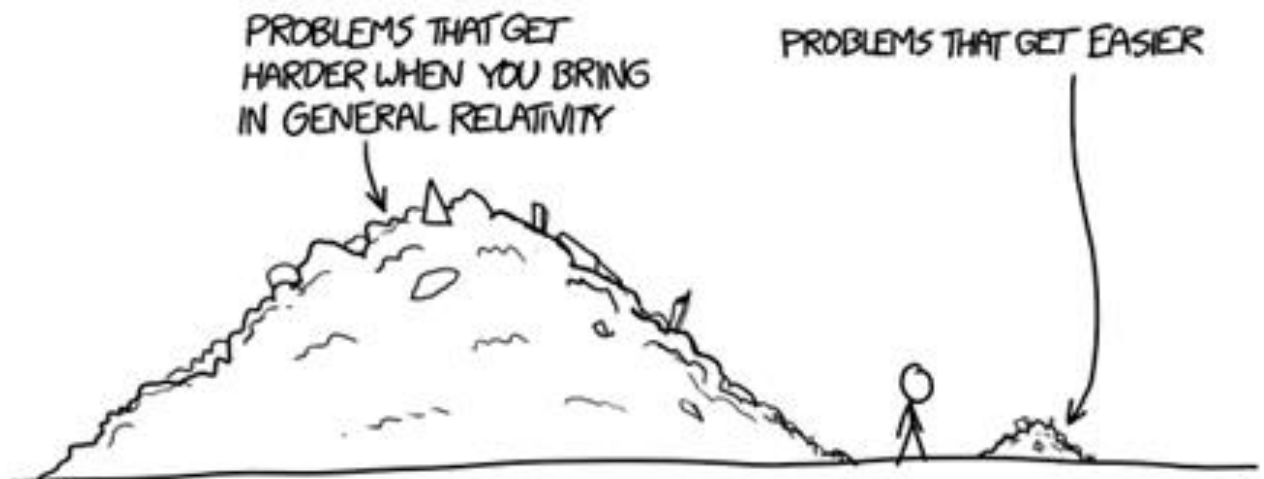
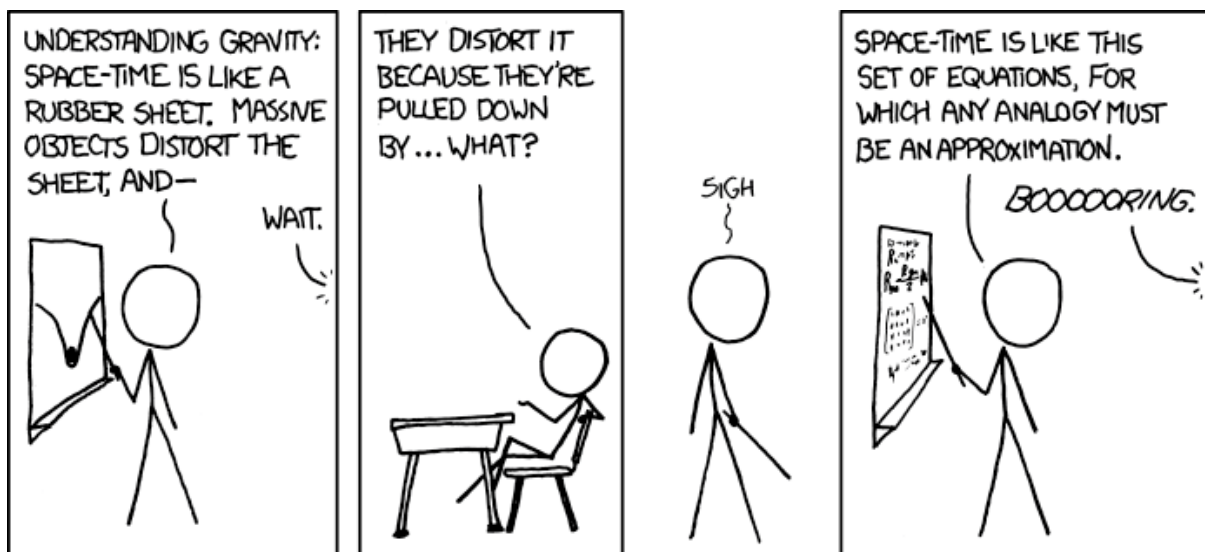


# Advanced Higher Physics

## Past Paper Questions

### 1.5 General Relativity



5. Einstein's theory of general relativity can be used to describe the motion of objects in non-inertial frames of reference. The equivalence principle is a key assumption of general relativity.

(a) Explain what is meant by the terms:

(i) *non-inertial frames of reference*;

1

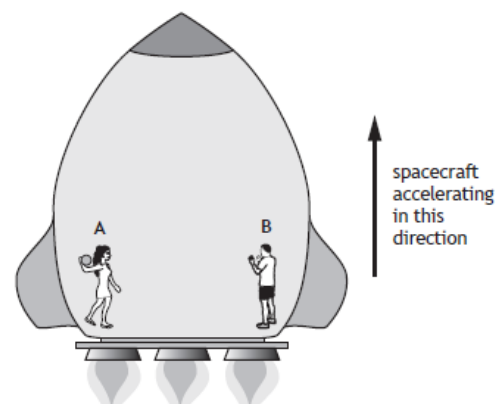
(ii) *the equivalence principle*.

1

(b) Two astronauts are on board a spacecraft in deep space far away from any large masses. When the spacecraft is accelerating one astronaut throws a ball towards the other.

(i) On Figure 5A sketch the path that the ball would follow in the astronauts' frame of reference.

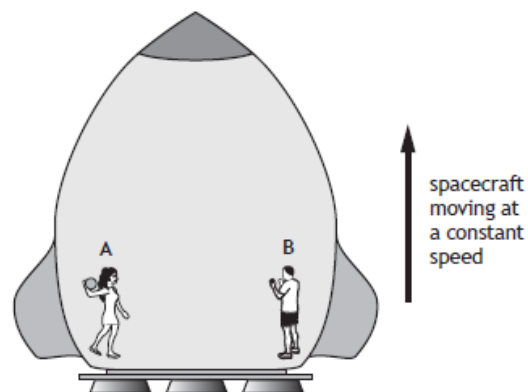
1



(ii) The experiment is repeated when the spacecraft is travelling at constant speed.

On Figure 5B sketch the path that the ball would follow in the astronauts' frame of reference.

1



(c) A clock is on the surface of the Earth and an identical clock is on board a spacecraft which is accelerating in deep space at  $8 \text{ m s}^{-2}$ .

State which clock runs slower.

Justify your answer in terms of the equivalence principle.

2

- (a) The world lines for three objects A, B and C are shown in Figure 6A

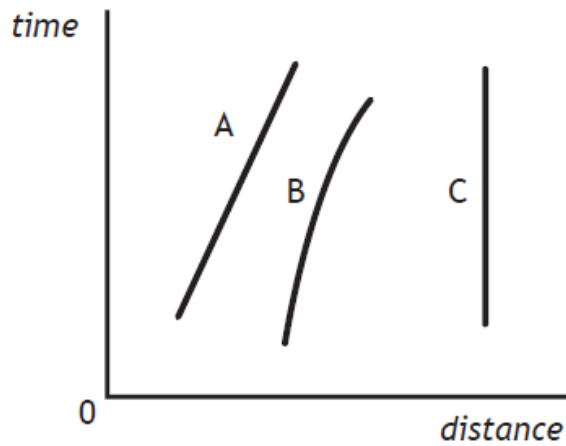


Figure 6A

To which of these objects does the General Theory of Relativity apply? Explain your choice.

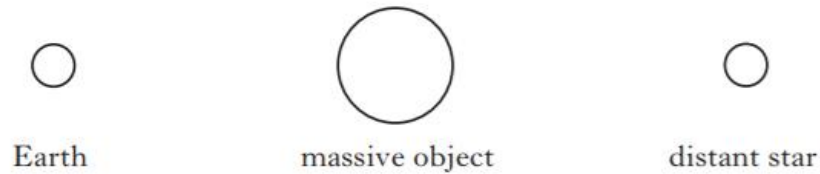
2

- (b) A rocket ship is accelerating through space. Clocks P and Q are at opposite ends of the ship as shown in Figure 6B. An astronaut inside the rocket ship is beside clock P and can also observe clock Q.

2. (a) With reference to General Relativity, explain why the Moon orbits the Earth. 2

(b) General Relativity also predicts gravitational lensing.

Figure 2 shows the relative positions of Earth, a massive object and a distant star.



**Not to scale**

Figure 2

Copy the diagram. On your diagram show:

(i) the path of light from the star to Earth; 1

(ii) the observed position of the star from Earth. 1

(c) Two students visit the tallest building on Earth. Student A takes a lift to the top of the building while student B waits at the bottom. General Relativity predicts that time will not pass at the same rate for both students. For which student does time pass at a slower rate?

You must justify your answer. 2

**(6)**

5. A commercial airline pilot talking to his friend, who is a member of the ground crew, states

*“Of course, according to Einstein’s theories, flying at high speed at high altitude means that I’m going to age much slower than you will.”*

Using your knowledge of physics principles, comment on the pilot’s statement. (3)

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4. (a) The world lines for three objects A, B and C are shown in Figure 4A.

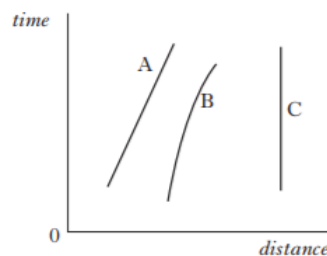


Figure 4A

To which of these objects does the General Theory of Relativity apply? Explain your choice. 2

- (b) A rocket ship is accelerating through space. Clocks P and Q are at opposite ends of the ship as shown in Figure 4B. An astronaut inside the rocket ship is beside clock P and can also observe clock Q.

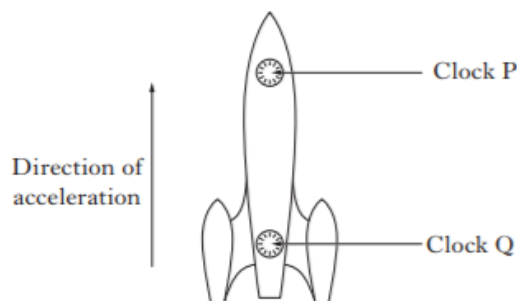


Figure 4B

What does the astronaut observe about the passage of time for these clocks? Justify your answer. 2

- (c) Part of an astronaut’s training is to experience the effect of “weightlessness”. This can be achieved inside an aircraft that follows a path as shown in Figure 4C.



Figure 4C

Use the equivalence principle to explain how this “weightlessness” is achieved. 2

