

**UNIVERSITY OF SURREY  
FACULTY OF ENGINEERING AND PHYSICAL SCIENCES  
DEPARTMENT OF PHYSICS**

**BSc and MPhys Programmes in Physics**

**LEVEL HE1  
SPACE, TIME AND RELATIVITY**

**MOCK TEST**

**50 minutes**

**Answer ALL questions**

<p><b>The correct answer carries 2 marks, “don’t know/blank” carries 0 marks and the wrong answer carries -1/2 mark</b></p>
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**Internal Examiner: Professor J S Al-Khalili**

**The only University approved calculators are Casio Models FX115MS,  
FX115W or FX115S for September 1998 entry onwards.**

1. In 1905, Einstein explained that the Michelson-Morley experiment had
- (a) not been carried out correctly
  - (b) shown that a preferred frame of reference must exist
  - (c) shown that the speed of light is constant in all inertial reference frames
  - (d) shown that the speed of light is constant in all direction in one inertial frame
  - (e) the ether was difficult to detect

Answer

2. A body moving with a relativistic gamma factor of 4 in some frame must be travelling relative to that frame at a speed of
- (a) 80.5 % of the speed of light
  - (b) 90.2 % of the speed of light
  - (c) 96.8 % of the speed of light
  - (d) 99.3 % of the speed of light
  - (e) 99.95 % of the speed of light

Answer

3. A javelin in flight is seen in some frame to be length contracted to 96% of its proper length. Its speed in this frame must be
- (a)  $0.28 c$
  - (b)  $0.44 c$
  - (c)  $0.16 c$
  - (d)  $0.62 c$
  - (e)  $0.88 c$

Answer

4. The distance to a star as seen by a fast moving spaceship appears to be length contracted to 4 light-years. If the ship is travelling at a speed of  $0.8c$ , the proper distance to the star is
- (a) 2.33 light-years
  - (b) 3.67 light-years
  - (c) 4 light-years
  - (d) 6.67 light-years
  - (e) 8.33 light-years

Answer

CONTINUED ON NEXT PAGE

5. Two events take place on Earth and the Moon, which are  $4 \times 10^5$  km apart. An observer on Earth measures the proper time between the two events to be one second, with the Earth event earlier. A second observer, moving at a speed of  $0.6c$  relative to the first sees
- (a) the Earth event 0.25 secs before the Moon event
  - (b) the Earth event 1.25 secs before the Moon event
  - (c) the Earth event 0.25 secs after the Moon event
  - (d) the Earth event 4 secs before the Moon event
  - (e) the Earth event 2 secs after the Moon event

[You may use the Lorentz Transformation  $\Delta t' = \gamma(\Delta t - v_0 \Delta x/c^2)$ .]

Answer

6. A source of light with frequency  $f_0$  is travelling away from an observer at a speed of  $0.9c$ . The observer will see it receding with a relativistically Doppler shifted frequency of
- (a)  $4.36f_0$
  - (b)  $3f_0$
  - (c)  $0.125f_0$
  - (d)  $0.053f_0$
  - (e)  $0.23f_0$

Answer

7. For a subatomic particle of rest mass  $m_0$  travelling at half the speed of light, the non-relativistic value of its momentum will be in error by
- (a) 25 %
  - (b) 13.4 %
  - (c) 15.4 %
  - (d) 33.3 %
  - (e) 56.7 %

Answer

CONTINUED ON NEXT PAGE

8. The relativistic kinetic energy of a proton, of rest mass  $m_p$ , is  $6 m_p c^2$ . It must therefore be travelling at a speed of
- (a)  $0.986 c$
  - (b)  $0.9897 c$
  - (c)  $0.9798 c$
  - (d)  $0.9676 c$
  - (e)  $0.9989 c$

Answer

9. In order that the kinetic energy of a body to be exactly half its total energy, it must be travelling at a speed of

- (a)  $\frac{\sqrt{8}}{3} c$
- (b)  $\frac{\sqrt{5}}{3} c$
- (c)  $\frac{\sqrt{3}}{5} c$
- (d)  $\frac{\sqrt{2}}{3} c$
- (e)  $\frac{\sqrt{3}}{2} c$

Answer

10. Two rockets are travelling at speeds of 80% and 90% the speed of light towards each other according to an independent observer. On board either rocket, the other will be seen approaching at a speed of
- (a)  $0.143c$
  - (b)  $0.998c$
  - (c)  $0.988c$
  - (d)  $0.908c$
  - (e)  $1.7c$

[Hint: for Q10 you may use the velocity transformation equation  $v_x = \frac{v'_x + v_0}{1 + v'_x v_0 / c^2}$ .]

Answer

**END OF TEST PAPER**