Physics 370 Name:_____

October 5, 2016 **Exam 1** 16 questions, 76 points

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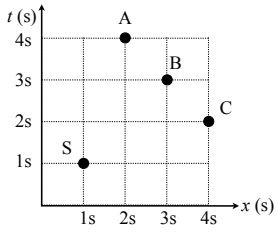
[3] 1. Explain the difference between inertial and noninertial reference frames.

[3] 2. _____ Which runs more slowly?
A) a clock on top of a mountain **B)** a clock at the base of the mountain
C) It depends on where the observer is

3. The graph shows four events, in $c = 1$ units.



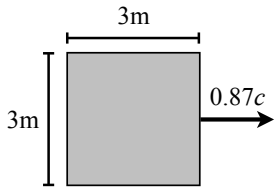
[3] (a) _____ Which event(s) could be simultaneous with S in *some* other frame? (That is, for which event(s) does there exist a frame such that S and that event are simultaneous?)

A) A **B)** B **C)** C **D)** none
E) B and C **F)** A and B **G)** A, B, and C

[3] (b) Find the spacetime interval Δs between events S and A.

[2] (c) What is the spacetime interval Δs between events S and A, in a frame that is moving at speed $0.8c$ to the right?

4. A $3\,\text{m} \times 3\,\text{m}$ square (in its frame) is moving at $0.87c$ to the right in the "rest" frame (i.e. the frame of this paper).



3 (a) _____ What does the square look like in the rest frame?

A)  **B)**  **C)** 

3 (b) _____ What is the (horizontal) length of the square as seen in the rest frame?

A) 1.35 m **B)** 1.5 m **C)** 1.7 m **D)** 3 m **E)** 6 m

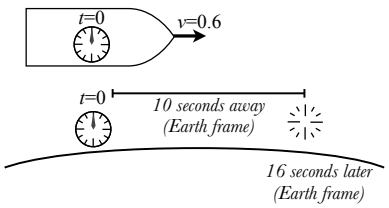
5. Passengers in a rocket travel to a distant star. It takes them 18 years to get there from our perspective, travelling at a velocity such that $\gamma = 1.5$.

3 (a) If event A is the moment the rocket leaves Earth, and event B is the moment the rocket arrives at the star, what is the distance $\Delta x'$ between those events, in the passenger's frame?

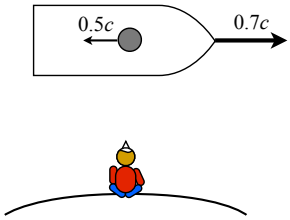
3 (b) _____ How long does it take to reach the star, from a passenger's perspective?

A) 9 years **B)** 12 years **C)** 15 years
D) 18 years **E)** 27 years **F)** 36 years

3 6. When a rocket moving at $0.6c$ in the $+x$ direction flies by an observer on Earth, clocks on the rocket and on Earth both read $t = 0$. According to the Earthly observer, a firecracker goes off 16 s later, at a distance of 10 s away (using $c = 1$ units). When the firecracker goes off, what time does the rocket observer see on her clock?



3 7. A rocket is travelling by the Earth at $0.7c$ to the right. Someone inside the rocket throws a ball that moves at $0.5c$ to the left, from their perspective. How fast is the ball moving in the Earth's frame, and in which direction?



3 8. _____ True or false: Massless particles can be deflected by a gravitational field.

[4] 9. Fill in the blanks in this paragraph:
The ultraviolet catastrophe was the paradox which predicted that a

_____ emits _____ energy, due to there being too may

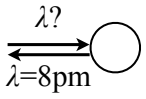
standing waves with _____ frequency. Planck solved the paradox by assuming that the energy of a given standing wave with frequency f must be

_____.

[3] 10. Explain the difference between the photoelectric effect and bremsstrahlung.
For the photoelectric effect,

while for bremsstrahlung,

[3] 11. _____ A gamma ray hits a stationary electron, and is reflected directly backwards with a wavelength of 8 picometers. What was the wavelength of the original gamma ray? (Note: $h/m_e c = 2.42\,\text{pm}$.)



A) 3.16 pm **B)** 5.58 pm **C)** 8 pm **D)** 10.42 pm **E)** 12.84 pm

12. Green light (500 nm) shines on metal, and a stream of (nonrelativistic) electrons are detected from the metal moving at 5×10^5 m/s.

[3] (a) How much energy does each photon of green light possess?

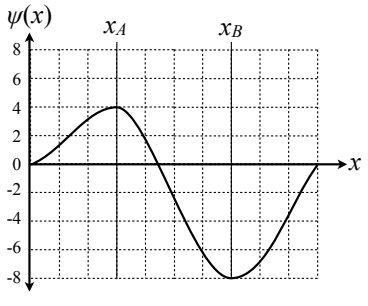
[3] (b) How much energy is required to liberate an electron from the surface of this metal?

[2] (c) _____ We could turn off the flow of electrons by changing the light's

A) brightness **B)** color **C)** polarization

[3] 13. _____ This graph shows a wavefunction $\psi(x)$. If $P(x)$ is the probability that the object will be found at position x, what is $P(x_A)/P(x_B)$?

A) 0.25 **B)** 0.5 **C)** 2 **D)** 4 **E)** 8



14. An electron and a positron are moving towards each other at $u = 0.6$ (in $c = 1$ units) and $\gamma = 1.25$. The rest mass of an electron to 0.5 MeV. Answer the following questions in $c = 1$ units.

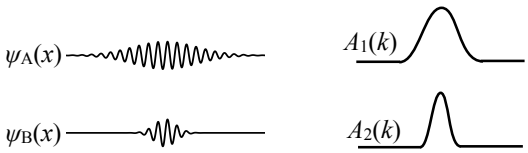
3 (a) What is the total energy of the electron, in MeV?

3 (b) What is the total kinetic energy of the electron, in MeV?

3 (c) What is the momentum of the electron, in MeV?

3 (d) When the two particles collide, two identical photons are emitted in opposite directions. What is the frequency f of each photon, in Hz? *(Be careful with the units here.)*

2 15. _____ The figures show two wavefunctions, $\psi_A(x)$ and $\psi_B(x)$, and their two Fourier transforms $A_1(k)$ and $A_2(k)$, not necessarily in that order. $A_1(k)$ is the Fourier transform of which of the wavefunctions?
A) $\psi_A(x)$ **B)** $\psi_B(x)$



16. Consider a plane wave, i.e. a solution to the forceless Schrodinger equation

$$-\frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial x^2} = i\hbar\frac{\partial\Psi}{\partial t}$$

with $k = 0.1\,/\text{m}$ and mass $9 \times 10^{-31}\,\text{kg}$.

3 (a) Find the plane wave's angular frequency ω.

3 (b) Write the plane wave $\Psi(x,t)$ in terms of x and t, and no other variables. Ignore the normalization constant.