Physics 101: Practice Final Exam

Problem 1

All of the following demonstrations are related to electricity. Which one was not preformed in class?

(a) Student's hair repelled apart when touching Van de Graaf generator

(b) Observed light bulb filament under microscope

(c) Watched 100-watt light bulb explode in a vacuum chamber

(d) Burned up a fuse by connecting several light bulbs in the same circuit

(e) Melted light bulb filament when used without surrounding glass

Answer: ~~A~~

Problem 2

The professor on the video discussing Black Holes made the interesting speculation that perhaps

(a) The outer 3 planets of our solar system are actually Black Holes

(b) There is a Black Hole in between our Sun and the planet Mercury

(c) There is a Black Hole at the center of our Sun

(d) There is a Black Hole at the center of the Milky Way galaxy

(e) Our entire universe is a Black Hole in someone else's universe

Answer: ~~D~~

Problem 3

An official Major League baseball weighs about 0.32 pounds (on the surface of the Earth). If all of its mass could be completely converted to energy, how many days could this energy run the entire United States? For purposes of this problem, assume the U.S. population is 300 million people, and that each person uses 500 watts continuously.

(a) about 1 day

(b) about 7 days

(c) about 30 days

(d) about 90 days

(e) about 1000 days

Answer: A
First, find the mass of the ball in kilograms. This is done by converting pounds to Netwons, then dividing by gravitational acceleration.

$$0.32 \text{ lbs} \left(\frac{1 \text{ N}}{0.2248 \text{ lbs}} \right) \left(\frac{1}{9.8 \text{ m/s}^2} \right) = 0.1453 \text{ kg}$$

From class, energy is related to the mass by

$$\text{Energy} = \text{mass} \left(\text{speed of light} \right)^2 \tag{1}$$

The energy from a baseball is

$$\text{Energy} = 0.1453 \text{ kg} \left(3 \times 10^8 \text{ m/s} \right)^2 = 1.307 \times 10^{16} \text{ J}$$

The amount of power from the baseball in one day is then energy divided by the time in a day

$$\text{Power} = \frac{\text{Energy}}{\text{time}} = \frac{1.307 \times 10^{16} \text{ J}}{86400 \text{ s}} = 1.513 \times 10^{11} \text{ W}$$

The amount of power consumed in the United States in a day is

$$\text{Power per person per day}\,(\text{Number of people}) = 500\ \text{W/person/day}\left(3\times10^{8}\ \text{People}\right) = 1.5\times10^{11}\ \text{W/day}$$

The number of days a baseball can power the United States is then

$$\text{number of days} = \frac{\text{power from baseball}}{\text{power per day}} = \frac{1.513\times10^{11}\ \text{W}}{1.5\times10^{11}\ \text{W/day}} \approx 1\ \text{day}$$

Problem 4

Because of its location on the Earth, attempting to receive satellite television signals at the North Pole would not work. Using your knowledge of the orbits these satellites have, and the information on the front page of this exam, calculate the direction a receiving dish would have to be pointed at the North Pole. (Pick the closest answer.)

(a) 6 degrees above the horizon

(b) exactly at the horizon

(c) 6 degrees below the horizon

(d) 9 degrees below the horizon

(e) 12 degrees below the horizon

Answer: D
The satellite and the North Pole form a triangle with the height of the triangle being the radius of the Earth (4000 miles) and the length being the distance of the satellite to the center of the Earth (26,300 miles). Using the inverse tangent to find the angle.

$$\tan\theta = \frac{4000\ \text{mi}}{26,300\ \text{mi}} \Rightarrow \theta = \tan^{-1}\frac{4000\ \text{mi}}{23,600\text{mi}} = 8.65^{\text{o}} \approx 9^{\text{o}}$$

Problem 5

On the first day of Spring, in Charlottesville, which one of the following phases of the Moon will reach the highest point in the sky?

(a) new Moon

(b) half-illuminated on the right

(c) full Moon

(d) half-illuminated on the left

Answer: B

Problem 6

"Reverberation" can be described as ———. Concert halls are designed to have how much reverberation?

(a) a single echo; as little as possible

(b) a single echo; as much as possible

(c) repeated reflections of sound; as little as possible

(d) repeated reflection of sound; a moderated amount

(e) repeated reflection of sound; as much as possible

Answer: D

max angle = 90 - Latitude + Title of Earth min angle = 90 - Latitude - Title of the Earth

Problem 7

As stated on your recent homework assignment: Use your knowledge and context of this to answer the following. Paris, France is located at 48.7 degrees north latitude. On the first day of summer, what is the shortest shadow that a 6-foot-tall person, standing vertically on level ground, will cast?

(a) 2.0 feet

(b) 2.2 feet

(c) 2.4 feet

(d) 2.6 feet

(e) 2.8 feet

Answer: E
Because it is summer, the maximum angle is the angle at noon time in the summer in the Northern Hemisphere. The angle is then $\theta = 90^{\circ} - 48.7^{\circ} + 23.5\text{o} = 64.8^{\circ}$. The length of the shadow is then

$$\tan\theta = \frac{\text{object}}{\text{shadow}} \Rightarrow \text{shadow} = \frac{\text{object}}{\tan\theta} = \frac{6 \text{ ft}}{\tan 64.8^{\circ}} = 2.82 \text{ ft}$$

Problem 8

You are standing in a bus, facing forward, at a stop sign. Suddenly the bus begins driving forward, and you feel like you are thrown backward. The force pulling you backward is

(a) air resistance

(b) friction between your shoes and the floor

(c) the inertia of the bus

(d) your inertia

(e) there is no force; you are observing from an improper frame of reference

Answer: E
Friction between your shoes and the floor is in the direction of the bus. The air resistance is not an effect, because the air has not moved with the bus, yet.

Problem 9

The astronauts in the orbiting Space Shuttle feel weightless because

(a) they are so far from Earth that the gravitational pull is negligible

(b) they are in free-fall, with an acceleration of 9.8 m/s^2

(c) they are in free-fall, with an acceleration of less than 9.8 m/s^2

(d) they are in free-fall, with an acceleration of greater than 9.8 m/s^2

Answer: C

Problem 10

A pilot is kidnapped from Earth by extra-terrestrials in 1945, flies around on a spaceship at high speed, and is returned to the Earth in 1977 (so that 32 years pass on Earth). Yet, the pilot has only aged 1 year. How fast, on average, must the spaceship have been traveling , as a percentage of the speed of light? (Make our usual approximation that the Earth is an inertial reference frame.)

(a) 95.951 % of the speed of light

(b) 96.951 % of the speed of light

(c) 97.951 % of the speed of light

(d) 98.951 % of the speed of light

(e) 99.951 % of the speed of light

Answer: E

From class, time dilation is

$$\Delta t_G = \frac{\Delta t_T}{\sqrt{1-(v/c)^2}} \tag{2}$$

Solving for v/c

$$\Delta t_G = \frac{\Delta t_T}{\sqrt{1-(v/c)^2}} \Rightarrow 1-(v/c)^2 = \left(\frac{\Delta t_T}{\Delta t_G}\right)^2 \Rightarrow v/c = \sqrt{1-\left(\frac{\Delta t_T}{\Delta t_G}\right)^2}$$

In this problem, $\Delta t_T = 1$ year and $\Delta t_G = 32$ years, then

$$v/c = \sqrt{1-\left(\frac{1 \text{ year}}{32 \text{ years}}\right)^2} = .999512$$

Problem 11

A 150-pound person is climbing on a "StairMaster". If each step is 23 centimeters high, and the person climbs at a rate of 80 steps per minute, how many food calories will the person burn in 30 minutes, assuming his body is 20% efficient at converting food calories into useful work?

(a) 18

(b) 88

(c) 165

(d) 329

(e) 440

Answer: E

The amount of work is

$$\text{Work} = \text{Force} \times \text{distance} \tag{3}$$

The amount of force is 150 lbs, but this needs to be converted to SI units, so 150 lbs = 667.26 N from 1 N = 0.2248 lbs near the surface of the Earth. The distance is

$$\text{distance} = \text{height/step} \times \text{steps/min} \times \text{min} = 0.23 \text{ m/step}\,(80 \text{ steps/min})\,(30 \text{ min}) = 552 \text{ m}$$

The amount of work in Joules is

$$\text{Work} = \text{Force} \times \text{distance} = 667.26 \text{ N}\,(552 \text{ m}) = 368328 \text{ J}$$

The number amount of work in food calories is 368328 J = 87.99 food cal from 1 food cal = 4186 J. The total energy is

$$\text{Total Energy} \times \text{Efficiency} = \text{Work} \Rightarrow \text{Total Energy} = \frac{\text{Work}}{\text{Efficiency}} = \frac{87.99 \text{ food cal}}{0.20} = 440 \text{ food cal}$$

Problem 12

During the Science Fiction lectures, we watched Superman perform several amazing feats. Which one of them was followed up by video of a very similar stunt by "Homer Simpson" of the TV animated series "The Simpsons"?

(a) saving a school bus form a crashing off a bridge

(b) catching a woman who has just fallen from a building

(c) lifting a very large rock over his head

(d) using X-ray vision to inspect someone's lungs

(e) flying through the air with a blue cape hung from his shoulders

Answer: C

Problem 13

(For this problem, ignore air resistance). Lois Lane falls from a building for 9 seconds, before Superman catches her and brings her to rest in 0.4 seconds. During this catch, Lois experiences a deceleration of

(a) 12.3 g's

(b) 17.8 g's

(c) 22.5 g's

(d) 27.0 g's

(e) 31.0 g's

Answer: C
The velocity that Lois reaches is given by

$$\text{velocity} = \text{acceleration} \times \text{time} + \text{initial velocity} \tag{4}$$

The initial velocity is 0, the acceleration is the acceleration of gravity, 9.8 m/s^2, and the amount of time is 9 s. The velocity is

$$\text{velocity} = 9.8 \text{ m/s}^2 \, (9 \text{ s}) = 88.2 \text{ m/s}$$

The acceleration the Lois feels from Superman catching her is

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{amount of time}} = \frac{88.2 \text{ m/s}}{0.4 \text{ s}} = 220.5 \text{ m/s}^2$$

The number of g's is

$$\frac{220.5 \text{ m/s}^2}{9.8 \text{ m/s}^2/\text{g}} = 22.5 \text{ g's}$$

Problem 14

In the film excerpt we watched from "20 Million Miles to Earth" a creature

(a) emitted green light from its eyes with no apparent source of energy

(b) withstood very high temperatures without being burned

(c) was transported 20 million miles in an impossibly short time

(d) was transported 20 million miles in the same amount of time it would take light to travel that distance

(e) grew to a large size with no apparent source of food

Answer: E

Problem 15

All of the following are related to magnetism. Which one was NOT shown in class as a demonstration?

(a) A compass needle deflected by a wire carrying electric current

(b) Lining up iron filings on the magnetic stripe of a New York City subway card

(c) Removing the coating from an audio cassette with a cotton swab dipped in fingernail polish remover

(d) Watching a small permanent magnet float over a superconductor

(e) Bouncing marbles on a loudspeaker

Answer: C

Problem 16

Humans ears hear best near which of the following frequencies?

(a) 20 Hz

(b) 90 Hz

(c) 4,000 Hz

(d) 13,000 Hz

(e) 20,000 Hz

Answer: C

Problem 17

During class we watched an extensive excerpt from an old (circa 1960's) video showing an experiment measuring the speed of electrons. The electrons were accelerated through various voltages, and their speeds were plotted on a graph. It was found that the actual results differed wildly from the prediction of the "classical" or Newtonian physics theory. In class, what was eventually revealed to be the incorrect assumption in the Newtonian theory?

(a) Newton's formula for kinetic energy was wrong

(b) Newton thought that electrons had the same mass as protons

(c) Newton thought that all electrons traveled at the speed of light

(d) Newton was using a value for the speed of light which was about 10 times too high

(e) Newton was using a value for the speed of light which was about 100 times to high

Answer: A

Problem 18

On a particular day in Charlottesville, you are looking towards the south and see the Moon in the position shown in the drawing. Approximately what time is it, using standard time (not daylight savings time)? (The white portion of the Moon is illuminated.)

(a) 6 am

(b) 10 am

(c) 2 pm

(d) 6 pm

(e) 10 pm

Answer: E

Problem 19

If an electron is accelerated through 3.82 million volts, it will gain kinetic energy of 6.112×10^{-13} Joules. Newtonian mechanics predicts that this electron will have a speed about four times the speed of light which is of course incorrect. Calculate the actual speed, as predicted by special relativity (and which is confirmed by experiment).

(a) 99.1 % of the speed of light

(b) 99.2 % of the speed of light

(c) 99.3 % of the speed of light

(d) 99.4 % of the speed of light

(e) 99.5 % of the speed of light

Answer: C
From class (hopefully), the relativistic kinetic energy is given by

$$\text{kinetic energy} = \text{mass} \times (\text{speed of light})^2 \times \left(\frac{1}{\sqrt{1 - \left(\frac{\text{velocity}}{\text{speed of light}}\right)^2}} - 1 \right) \tag{5}$$

Solving for the velocity

$$K = mc^2 \left(\frac{1}{\sqrt{1-(v/c)^2}} - 1 \right) \Rightarrow \sqrt{1-(v/c)^2} = \frac{1}{K/mc^2+1} \Rightarrow v/c = \sqrt{1 - \frac{1}{(K/mc^2+1)^2}}$$

The velocity is then

$$v/c = \sqrt{1 - \frac{1}{\left(\frac{6.112\times10^{-13}\ \text{J}}{9.1\times10^{-31}\ \text{kg}\left(3\times10^{8}\ \text{m/s}\right)^2} + 1\right)^2}} = .993$$

Problem 20

If the Moon is half-illuminated on the left side as viewed from Charlottesville, where in the sky would you expect to find it at 6 am?

(a) just rising in the east

(b) just setting in the west

(c) high up in the southern half of the sky

(d) high up in the northern half of the sky

(e) below the horizon, so you would not be able to see it

Answer: C

Problem 21

In your reading on magnetism in Ostdiek and Bord, which of the following was NOT covered?

(a) Use of strong magnets in shoes and their purported medical effects

(b) Electromagnets and their use in doorbells

(c) The use of magnets in particle accelerators such as Fermilab in Illinois

(d) The construction of loudspeakers

(e) Digital sound reproduction as used by CDs and DVDs

Answer: A

Problem 22

A 75-Watt light bulb and a 1000-Watt hairdryer are wired in parallel to a 120-volt power supply. What is the total current supplied by the power supply? (Pick the closet answer.)

(a) 4 amps

(b) 6 amps

(c) 8 amps

(d) 9 amps

(e) 11 amps

Answer: D
The power for an electrical circuit is

$$\text{power} = \text{voltage} \times \text{current} \tag{6}$$

Solving for the current

$$\text{current} = \frac{\text{power}}{\text{voltage}}$$

For the light bulb, current = 75 W/120 V = 0.625 A, and the hairdryer, current = 1000 W/120 V = 8.333 A. The total current is then the sum of the two, 8.958 A.

Problem 23

In the previous problem, what is the resistance of the light bulb? Of the hairdryer?

(a) 192 ohms; 14.4 ohms

(b) 14.4 ohms; 192 ohms

(c) 13.4 ohms; also 13.4 ohms

(d) 144 ohms; 19.2 ohms

(e) 19.2 ohms; 144 ohms

Answer: A
From Ohm's law,

$$\text{voltage} = \text{current} \times \text{resistance} \tag{7}$$

The amount of resistance is then

$$\text{resistance} = \frac{\text{voltage}}{\text{current}}$$

For the light bulb, resistance = 120 V/0.625 A = 192 ohms, and for the hairdryer, resistance = 120 V/8.333 A = 14.4 ohms.

Problem 24

Which of the following is NOT true about gravity?

(a) Clocks run slower in more intense gravitational fields

(b) Horizontal speed has no effect on vertical gravitational acceleration

(c) Gravity is the strongest force in the universe

(d) The gravitational force becomes weaker as you move

Answer: C

Problem 25

Einstein proposed two postulates of Special Relativity. Meanwhile, one conventional hypothesis said that the ether did not exist ("no ethet") while another said that there was an ether ("yes ether"). His postulate regarding frame of reference fit within the conventional —— hypothesis. His postulate regarding the speed of light fit within the conventional —— hypothesis.

(a) yes ether; yes ether

(b) yes ether; no ether

(c) no ether; yes ether

(d) no ether; no ether

Answer: C

Problem 26

The "solstice" is named after the time(s) of the year when

(a) the Earth slows in its orbits around the sun

(b) the Earth speeds up in its orbit around the sun

(c) the change in the effective tilt of the Earth is most rapid

(d) the change in the effective tilt of the Earth is least rapid

(e) Isaac Newton first "solved" the mathematical problem of planetary orbits

Answer: D

Problem 27

A person throws a ball upward and it eventually falls back to the person's hand. The following question pertains to the ball's flight just after it leaves the person's hand, until just before it falls back into his hand: On the way up the ball's acceleration is ———, at the top the acceleration is ———, and on the way down its acceleration is ———.

(a) upward; zero; downward

(b) downward; zero; downward

(c) upward; downward; downward

(d) downward; downward; downward

(e) downward; zero; downward

Answer: D

Problem 28

Which one of the following statements best describes the "Doppler effect"?

(a) It applies to sound but not to light

(b) It applies to light but not to sound

(c) It applies to both sound and light

(d) It applies to neither sound nor light

Answer: C

Problem 29

The newest U.S. paper currency contains a strip which "fluoresces" when exposed to ultraviolet light. Therefore, when illuminated by a "black light" the strip will emit which of the following? (This was demonstrated in class.)

(a) radio waves

(b) microwaves

(c) infrared light

(d) visible light

(e) ultraviolet light

Answer: D