

Practice Midterm Exam 1A

Physics 100, Spring 2007

Test Date: Wednesday, February 14, 2007

Useful Equations and Numbers

Acceleration due to gravity...

on Earth = 10 m/s^2

on Mars = 3.7 m/s^2

on the Moon = 1.6 m/s^2

$$(\text{change in position}) = \frac{1}{2} \times (\text{acceleration}) \times (\text{time})^2$$

$$(\text{change in speed}) = (\text{acceleration}) \times (\text{time})$$

$$(\text{speed}) = \frac{(\text{distance traveled})}{(\text{time})}$$

$$(\text{acceleration}) = \frac{(\text{change in velocity})}{(\text{time})}$$

$$(\text{force of gravity}) = (\text{mass}) \times (\text{acceleration due to gravity})$$

$$\text{speed of light} = 299,790,000 \text{ m/s}$$

$$20 \text{ m/s} = 45 \text{ mph}$$

$$1 \text{ mile/minute} = 60 \text{ mph}$$

$$1 \text{ pound of force} = 1 \text{ Newton}$$

$$1 \text{ km} = 0.6 \text{ miles}$$

$$1 \text{ furlong} = 201 \text{ meters}$$

$$1 \text{ hour} = 3,600 \text{ seconds}$$

$$1 \text{ minute} = 60 \text{ seconds}$$

$$1 \text{ g} = 10 \text{ m/s}^2$$

$$1 \text{ m/s} = 3.6 \text{ km/hour}$$

$$1 \text{ Newton} = 1 \frac{\text{kg m}}{\text{s}^2}$$

$$1 \text{ m} = 3.2 \text{ feet}$$

$$1 \text{ Joule} = 10,000,000 \text{ ergs}$$

$$\sqrt{200} = 14.14$$

$$\frac{5}{3} = 1.667$$

$$\frac{4}{5} = 0.800$$

$$\frac{1}{6} = 0.167$$

**DO NOT OPEN EXAM UNTIL INSTRUCTED TO DO SO!
TURN OFF YOUR CELL PHONE!**

Answer Key for Exam A

Section 1. True/False (2 pts. each)

Warm up!

- False An object has higher inertia the faster it moves. This is why it's harder to stop an object that's moving fast than one is moving slow.
- True Measuring the acceleration of gravity helps prospectors find oil fields and salt mines.
- False Aristotle invented the concept of inertia.
- False Galileo agreed with Aristotle that objects fell to the ground with a speed proportional to their weight, but did not believe that it was because they were made of predominantly of the element *earth*, as Aristotle did.
- False An object is in mechanical equilibrium whenever its instantaneous speed is zero.
- True An object is in equilibrium if the vector sum of all forces acting on it is zero (i.e. all forces acting on it cancel each other out).
- True In the simplest sense, a force is a push or a pull.
- True Whenever an object has a non-zero net force, it is accelerating.

Section 2. Fill-in-the-Blanks (3 pts. each)

Note: The size of the blank does not vary with the length of the answer.

1. When any object is in mechanical equilibrium, the sum of all forces acting on that object (F_{net}) is equal to zero.
2. A jet airplane is flying through the air with constant velocity. It's engines are providing a thrust of 9,900 lbs. The only other force acting on the jet is air resistance, which must be providing a force of 9,900 lbs in a direction opposite to the direction of the jet thrust.
3. Most generally, acceleration is defined as the change in velocity per time interval. If we are discussing motion along a straight line, then acceleration is equivalent to the change in speed per time interval.
4. If you were to walk by stepping 1 meter in 0.5 seconds, your speed would be 2 m/s.
5. Acceleration is directly (*directly/ indirectly*) proportional to mass.
6. The net force acting on a 1 kg ball in free fall is 9.8 or 10 N.

Section 3. Multiple Choice (2 pts. each)

Choose the single best answer unless instructed to do otherwise.

Hint: they're not all (C)!

7. Speed is defined as which of the following?

(a) $speed = \frac{\text{change in distance}}{\text{change in time}}$

(b) $speed = \frac{\text{change in velocity}}{\text{change in time}}$

(c) $speed = \frac{1}{2}gt^2$

(d) $speed = \frac{\text{change in distance}}{\text{change in position}}$

8. What Aristotelian idea did Galileo discredit in his fabled Leaning Tower of Pisa demonstration?

(a) The Earth is the center of the Universe

(b) Natural Motion

(c) Objects fall at rates proportional to their masses

(d) Everything is created from differing amounts of the five elements: *fire, water, earth, air, quintessence (aether)*

9. Something is in equilibrium if...

(a) ... it is moving at a constant speed.

(b) ... it is moving with a constant acceleration.

(c) ... only if it is not moving.

(d) ... it is moving at constant velocity.

10. In which of the following situations would a motorcycle be accelerating (check all that apply)

(a) Driving around a corner at 20 m/s

(b) Jumping off of a ramp

(c) Slowing down to avoid the kitten that jumped into the road

(d) Speeding up once the kitten crosses the road

(e) driving straight ahead at 40 m/s

11. Two identical-twin parachutists are skydiving. They weigh exactly the same and are wearing the same clothes, but the parachute of one is larger than the parachute of the other (though the parachutes also weigh the same). Which twin will fall with the greatest speed?

(a) The one with the smaller parachute.

(b) The one with the larger parachute.

(c) They will fall at the same speed.

(d) There is not enough information.

Section 4. **Short Answer Questions (5 pts. each)**

Show your work for all calculations. Partial credit is a good thing!

12. If you push on a crate with a force of 75 N and it slides at constant velocity, with how much force is the friction acting on the crate?

Answer: Because the crate is moving at constant **velocity**, that means it is moving with both a constant speed in a constant direction. Hence it is in equilibrium (dynamic equilibrium). Since it is in dynamic equilibrium, the net force acting on it must be zero. Therefore, friction must be canceling the force you are providing. In other words, friction is providing 75 N of force in the opposite direction you are pushing the crate.

13. If you are driving from San Francisco, (A) how would you determine your average speed for the trip?

Answer: You would use your odometer to measure how far you drove, and your watch to measure how much time it took. Your average speed would be given by dividing the distance by the time: $average\ speed = \frac{total\ distance}{total\ time}$.

14. (A) As you stand on a floor, does the floor exert an upward force against your feet? If so, (B) how much force does it exert and (C) why are you not lifted up by this force?

Answer: (A) Yes, the force exerts an upward force against your feet– a ‘support’ or ‘normal’ force. It is what keeps you from falling through the floor. (B) The force it exerts is equivalent to your weight. (C) You are not lifted up by this force, because gravity is canceling it out.

15. Burl makes careful measurements of a cannonball falling from a 50 m high building on Planet Newton. During the first second of it falling, he observes that the speed of the cannonball goes from 0 m/s to 4 m/s. (A) By how much will the cannonball's speed increase during the third second? (B) How long will it take for the cannonball to hit the soil of Planet Newton? (C) How fast will it be traveling when it does hit?

Answer: (A) The cannonball will increase its speed by 4 m/s during every second of free-fall (a cannonball is quite heavy and aerodynamic, so we may assume it's free-falling; we can ignore air resistance). This applies to the third second, as well as the first, and every second of free-fall. (B) We can use the relationship for distance fallen by an object starting at rest and undergoing free-fall:

$$(\text{distance traveled}) = \frac{1}{2}(\text{acceleration}) \times (\text{time})^2$$

We know it travels 50 m and it accelerates at 4 m/s² (that's what it means to change speed by 4 m/s every second!). So we would have:

$$50 \text{ m} = \frac{4 \text{ m/s}^2}{2} \times (\text{time})^2$$

Or

$$\begin{aligned} \frac{2 \times 50 \text{ m}}{4 \text{ m/s}^2} &= (\text{time})^2 \\ \frac{100}{4} \text{ s}^2 &= (\text{time})^2 \\ 25 \text{ s}^2 &= \text{time}^2 \end{aligned}$$

finally:

$$\text{time} = \sqrt{25 \text{ s}^2} = 5 \text{ s}$$

So the cannonball falls for 5 seconds. (C) As determined in (A), the cannonball will increase its speed by 4 m/s every second of free-fall. Since it starts at rest, its final speed after falling 5 seconds will be 20 m/s.

16. (A) What is the weight of a 1 kg brick on the surface of the Earth? (B) What is the weight of a 1 kg brick on the surface of Mars? (C) What is the mass of a 1 kg brick on the surface of the Moon?

Answer: The weight of something is equal to its mass multiplied by the gravitational acceleration it's experiencing. (A) On Earth, a 1 kg brick weighs $(1 \text{ kg}) \times (9.8 \text{ m/s}^2) = 9.8 \text{ N}$ (10 N is also perfectly acceptable). (B) On the surface of Mars, the acceleration due to gravity is only 3.7 m/s² (this can be found on Page 1). Therefore, a 1 kg brick would weigh 3.7 N on the surface of Mars. (C) The mass of an object does not depend on where it is or what gravitational field it's in. So a 1 kg brick has a mass of 1 kg everywhere, including on the surface of the Moon.

17. Can the velocity of an object reverse direction while maintaining a constant acceleration? If so, give an example; if not, provide an explanation.

Answer: Yes! Absolutely! An example of this is a ball thrown straight up in the air. Once it has left the hand that tossed it, it is only acting under the force of gravity (ignoring air resistance) and therefore constantly accelerating downward at 1 g, or $\sim 10 \text{ m/s}^2$. We all know that gravity will eventually slow the ball down and reverse its direction.

18. You hold a small, smooth metal ball for a few seconds before throwing it straight up into the air and catching it again. Fill out the following table: (i) List all of the forces acting on the ball (ii) the direction of the net force, F_{net} (0/UP/DOWN), (iii) the direction of the velocity and (iv) acceleration of the ball (0/UP/DOWN), and (v) state whether it's in equilibrium (YES/NO) during (A) the time it is sitting at rest in your hand for a few seconds, (B) the time which your hand is accelerating the ball, (C) the time after the ball has left your hand and is rising into the air, (D) the time at which the ball is at the top of its trajectory, (E) the time the ball is falling back down, and (F) the time during which you are catching the ball in your hand. *Ignore the effects of air resistance.*

	All the Forces	Dir. F_{net}	Dir. veloc.	Dir. acc.	Equilibrium?
A	gravity, support force	0	0	0	YES
B	gravity, support force	UP	UP	UP	NO
Answer: C	gravity	DOWN	UP	DOWN	NO
D	gravity	DOWN	0	DOWN	NO
E	gravity	DOWN	DOWN	DOWN	NO
F	gravity, support force	UP	DOWN	UP	NO