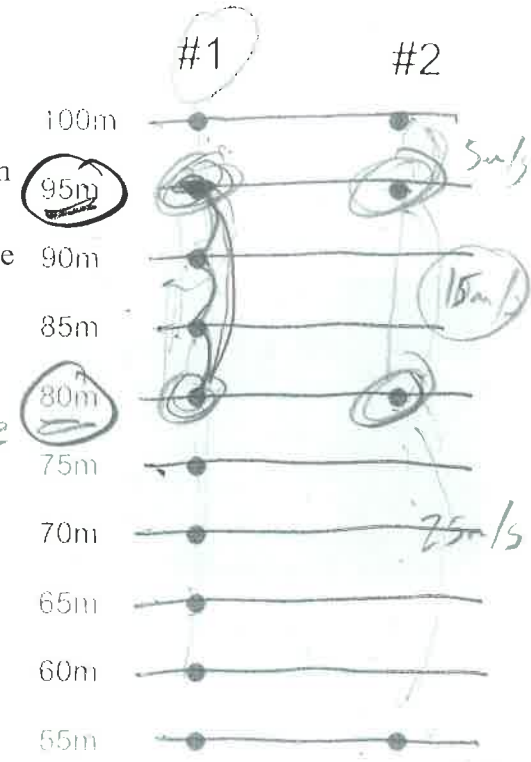


Note: If you can correctly complete all of the portions of this review – and if you understand the underlying concepts – then you can be confident that you will perform well on the final. Some of these questions may be very similar or identical to the exam questions, but others may be different ways of applying the same concepts.

Part I:

1. The dots to the right represent the positions of two 50kg base jumpers, recorded during each second of their fall. The distances on the left represent their heights. One of them is in free fall. The other has a parachute open and is falling with constant velocity. The jumpers jumped from a height of 100m.



a. What is “free fall?”

Falling without Air Resistance

b. Which jumper is in “free fall?”

#2

c. What are the average velocities of the jumpers between the 95m and 80m positions?

#1 velocity = $\frac{d}{t} = \frac{15m}{3s} = 5m/s$

#2 velocity = $\frac{d}{t} = \frac{15m}{1s} = 15m/s$

d. Fill in the table below for jumper #1.

Jumper 1 (mass = 50kg)			
Height	PE = mgh	KE = $\frac{1}{2}mv^2$	Total E
100m	50,000 J	625 J	50,625 J
80m	40,000 J	625 J	40,625 J
55m	27,500 J	625 J	28,125 J

loses Energy

or 0;

Doesn't lose energy!

e. If you were to fill out the table above for jumper #2, how would it look different?

KE would increase and Total E would be constant

f. Why?

No friction stealing energy during free fall

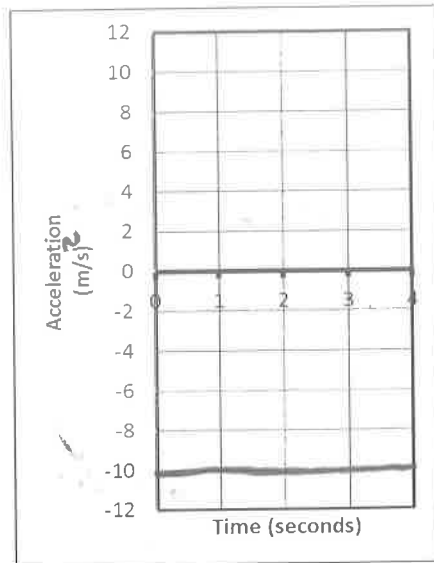
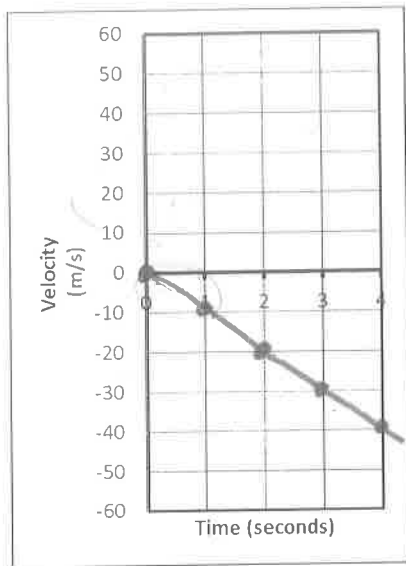
g. Describe the work that is being done on jumper #2 and describe the effect of that work.

Gravity applies a force over a distance.

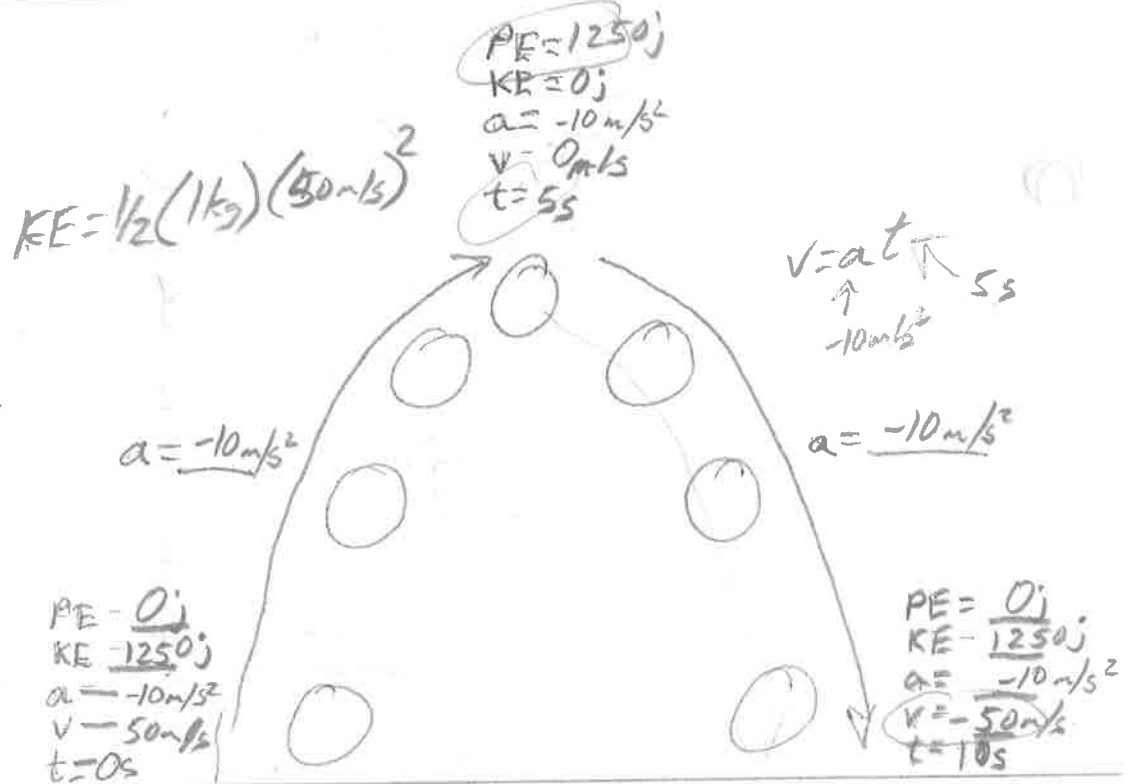
~~h. Describe the work that is being done on jumper #1 and describe the effect of that work..~~

~~*Gravity pulls down. Friction pushes up > cancel one another out*~~

2. Suppose an object is dropped from a tall building. When the object is released, it begins to **free-fall**. On the velocity graph, below, show the object's velocity during the first 4 seconds of its fall. Then show the object's acceleration for the first four seconds. **Be sure that your signs are correct!**



3. A ball is thrown upward into the air. It goes up, and it comes down. Fill in the ball's potential energy, kinetic energy, acceleration, velocity, and time in each of the blanks in the diagram. Note that you are given the starting time and the ending time. You must figure out the rest. **Make sure to use correct signs!**



4. What is the difference between velocity and speed?

includes direction

5. If Matilda is driving her car at a speed of 40m/s, what is her approximate speed in miles per hour?

Double it. $40\text{m/s} \times 2 \Rightarrow 80\text{mph}$

If you want to be precise, $40\text{m/s} \left(\frac{2.24\text{mph}}{\text{m/s}} \right) = 89.6\text{mph}$

6. If I say that someone has a velocity of 6 m/s , what does that mean? [Do not just spell out 4 m/s ; demonstrate that you know what this really means by saying it in a different way.]

Travel 6 m for each second that goes by.

7. Agatha has an acceleration of 6 m/s^2 . What does that mean?

She adds 6 m/s to her velocity for each second that goes by.

8. You could use your car's odometer (blue arrow in diagram on right) to find your average velocity on a trip to New York.



- a. What formula would you use?

$$v = \frac{d}{t}$$

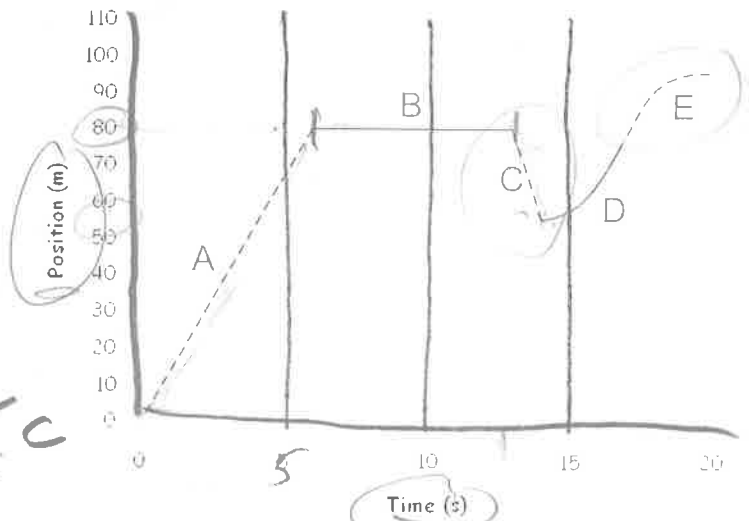
- b. What information would you find using the odometer?

distance

- c. What other information would you need?

time (how long)

- 9-12. The graph on the right shows the movement of an object relative to a motion sensor. The purpose of the alternating dotted and dashed lines is to allow you to distinguish between the lettered segments.

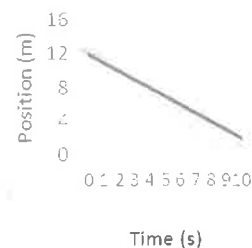
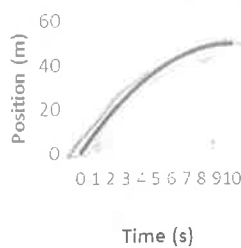
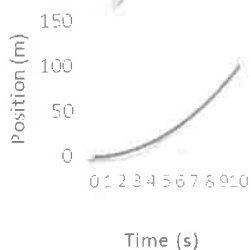
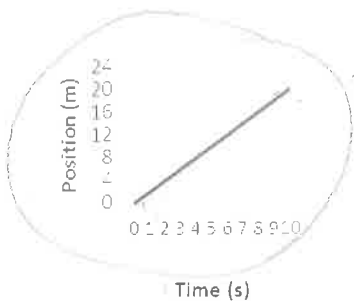


9. During which segment is the object motionless? **B**
10. During which segment is the object decelerating? **E**
11. During which segment does the object have the fastest constant speed (not velocity)? **A, C**
12. During which segment is the object moving backward? **C**
13. What was the average velocity during segment B?

0 m/s



14. Match each position vs. time graph to a velocity vs. time graph and an acceleration vs. time graph.



Velocity graph: B

Velocity graph: D

Velocity graph: A

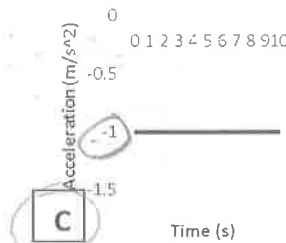
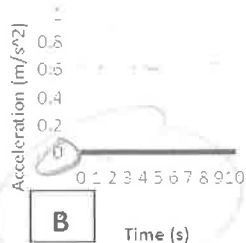
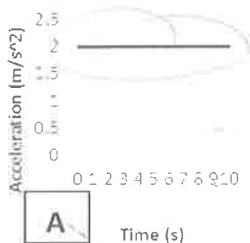
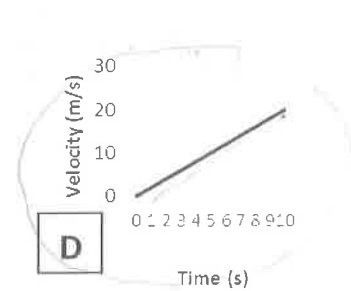
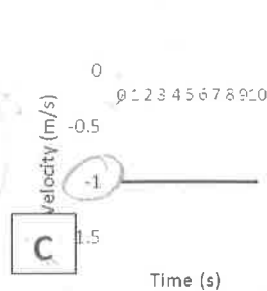
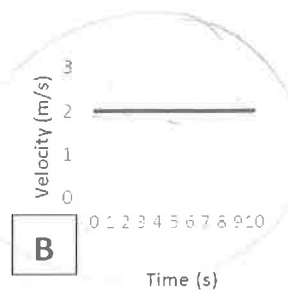
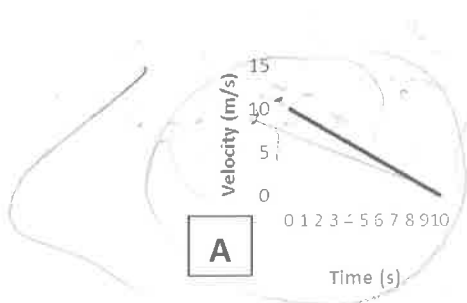
Velocity graph: C

Accel. graph: B

Accel. graph: A

Accel. graph: C

Accel. graph: B



15. An object travels 8 meters in the 1st second of travel 8 meters again during the 2nd second of travel and 8 meters again during the third second of travel. Its acceleration during this time period is:

a) 0 m/s²

b) 8 m/s²

c) 16 m/s²

d) 32 m/s²

16. When an object is in free-fall (i.e. neglecting any air resistance), which of the following apply(ies)?

a) velocity increases

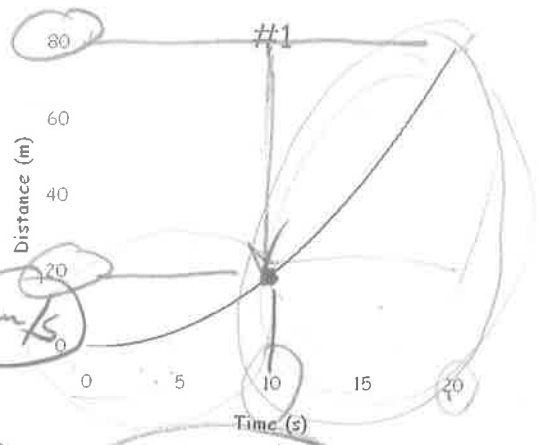
b) acceleration increases

c) speed increases

d) All of these

Part II:

1. The graph on the right shows the distance traveled by a bicyclist.



a. What was the average velocity of the bicyclist during the last 10 seconds (from 10s to 20s)?

$$v = \frac{d}{t} = \frac{(80m - 20m)}{(20s - 10s)} = \frac{60m}{10s} = 6m/s$$

b. What was the bicyclist's acceleration throughout the time period?

$$a = \frac{2d}{t^2} = \frac{2(80m)}{(20s)^2} = \frac{160m}{400s^2} = 0.4m/s^2$$

2. A rock falls from the edge of a cliff and hits the bottom 10 seconds later. How high is the cliff?

$$d = \frac{1}{2} a t^2 = \frac{1}{2} (-10m/s^2) (10s)^2 = -500m$$

↑ distance fallen ↑
500m

3. The world record for the women's 100 meters is 10.49 seconds set by Florence Griffith-Joyner on July 16, 1988. What was her average speed?

$$v = \frac{d}{t} = \frac{100m}{10.49s} = 9.53m/s$$

4. How long does it take Barbara to run from her Physics class to her French class? She runs with a speed of 3 m/s and the classes are 1000 m apart.

$$t = \frac{d}{v} = \frac{1000m}{3m/s} = 333s$$

5. Suppose a 75kg world class sprinter accelerates at a rate of $3 m/s^2$. Starting from a standstill, he eventually reaches a speed of $12 m/s$ on a flat, horizontal surface. During this acceleration, the sprinter undergoes a change in potential and kinetic energy. This is because the runner is doing work.

a. How long does it take the sprinter to accelerate to 12 m/s?

$$t = \frac{v}{a} = \frac{12m/s}{3m/s^2} = 4s$$

b. The runner's $\Delta PE =$

$$-5400j$$

This is "lost" as it turns into KE

c. What form of PE does/did the runner have?

Chemical energy

d. The runner's $\Delta KE =$

$$Final KE = \frac{1}{2} (75kg) (12m/s)^2 = +5400j$$

e. How far does the sprinter travel in the course of accelerating to 12m/s?

$$d = \frac{1}{2} a t^2 = \frac{1}{2} (3m/s^2) (4s)^2 = 24m$$

f. How much work does the sprinter do during this acceleration period?

$$Work = \Delta KE = 5400j$$

g. What average force was applied by the sprinter during the acceleration period?

$$W = fd \Rightarrow f = \frac{W}{d} = \frac{5400j}{24m} = 225N$$

$$f = ma = 75kg (3m/s^2) = 225N$$

PE turns to KE

6. A bumbling clown drops a rubber chicken from a height of 960. Assume that there is no air resistance.

a. What is the chicken's acceleration?

-10 m/s^2

$w = fd$

b. How long does the chicken take to fall to the ground?

$d = \frac{1}{2}at^2$

$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2(960\text{m})}{-10\text{m/s}^2}}$

13.8 s

c. How much work is done on the chicken while it is falling?

Work = $\Delta KE = 4800 \text{ J}$

$w = fd$
 $f = ma = 0.5 \text{ kg} (-10 \text{ m/s}^2) = -5 \text{ N}$
 $d = 960 \text{ m}$

d. What is the chicken's ΔPE (include correct sign)?

PE \rightarrow PE at top = $mgh = 0.5 \text{ kg} (10 \text{ m/s}^2) (960 \text{ m}) = 4800 \text{ J}$

e. What is the chicken's ΔKE (include correct sign)?

$+ 4800 \text{ J}$

PE @ bottom = 0

$\Delta PE = -4800 \text{ J}$

f. What is the velocity of the chicken just before it hits the ground (include correct sign)?

$v = at = (-10 \text{ m/s}^2) (13.8 \text{ s}) = -138 \text{ m/s}$

7. Is energy a vector quantity or a scalar quantity? Explain.

Scalar. Energy can't be negative. Energy does not have direction.

Part III:

Numbers 1-8 refer to the picture on the right, which shows a rubber band car. The graph shows how the car's velocity changed after it was wound up and released.



1. What was the car's acceleration during the acceleration phase?

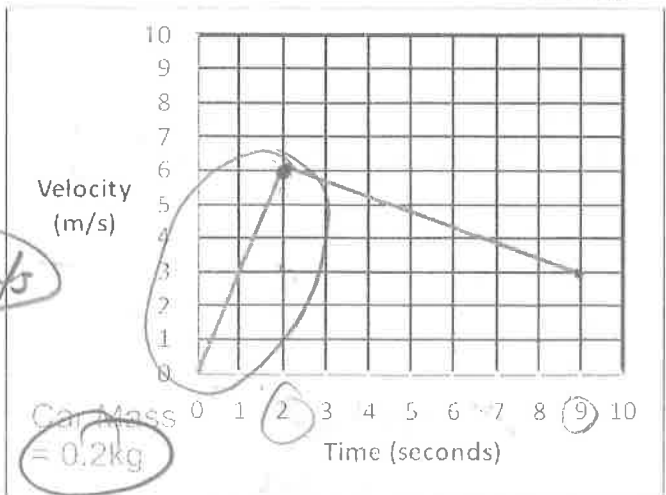
$a = \frac{\Delta v}{\Delta t} = \frac{6 \text{ m/s}}{2 \text{ s}} = 3 \text{ m/s}^2$

2. What was the car's acceleration during the deceleration phase?

$a = \frac{\Delta v}{\Delta t} = \frac{-3 \text{ m/s}}{7 \text{ s}} = -0.43 \text{ m/s}^2$

3. Complete the diagrams on the next page by entering the correct component forces and net forces for the acceleration and deceleration phases. ***You can assume that the motor force is zero during the deceleration phase.

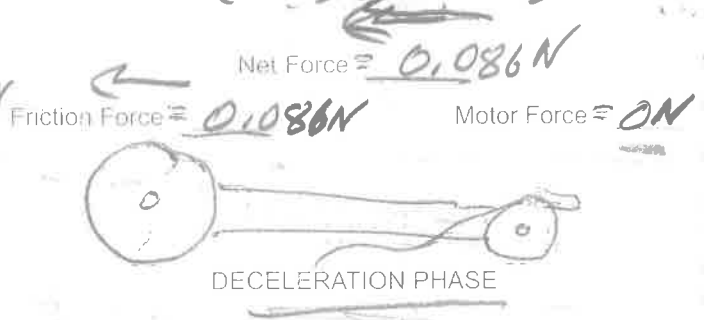
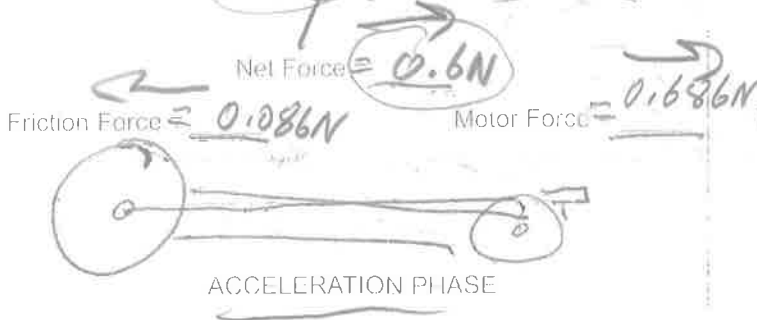
***You can also assume that the force of friction is the same during both phases.



Car Mass = 0.2 kg

$$F=ma = (0.2\text{kg})(3\text{m/s}^2) = 0.6\text{N}$$

$$f=ma = (0.2\text{kg})(-0.43\text{m/s}^2) = -0.086\text{N}$$



4. What was the car's maximum velocity? 6m/s

5. During the winding process, the rubber bands of the car above were stretched a distance of 0.35m . The average force required to stretch the rubber bands was 51N . How much work was done in the winding of the rubber bands?

$$\text{Output} = KE = \frac{1}{2}(0.2\text{kg})(6\text{m/s})^2$$

6. What was the car's energy input? 17.85J , Energy output? 3.6J , Efficiency? 20.1%

$$\text{Work} = fd = (51\text{N})(0.35\text{m}) = 17.85\text{J}$$

How much work did friction do during the deceleration phase? How do you know?

$$KE_{\text{beginning}} = 3.6\text{J} - KE_{\text{end}} = 0.9\text{J} = 2.7\text{J}$$

$KE_{\text{end}} = 0.9\text{J}$ ← KE last during decel = work by friction

According to the work and force of friction that you calculated, how far did the car travel during the deceleration period?

$$W = fd \rightarrow d = \frac{W}{f} = \frac{2.7\text{J}}{0.086} = 31\text{m}$$

by friction ← friction

9. A different car was accelerated by a net force of 40N . The car's acceleration was 6m/s^2 .

a. If the car's mass is doubled, but the force remains the same, what new acceleration should the car have?

$$3\text{m/s}^2$$

b. What is the car's mass?

$$f = ma \Rightarrow m = \frac{f}{a} = \frac{40\text{N}}{6\text{m/s}^2} = 6.67\text{kg}$$

Newton's 3rd Laws states that, for every action, there is an equal and opposite reaction.

10. What are the action and reaction forces that are involved when a skydiver falls to the Earth?

Earth pulls skydiver down; skydiver pulls Earth up. OR Air pushes diver up; diver pushes air down

11. What action and reaction forces are involved when a person walks northward?

Person pushes ground southward; ground pushes person northward

12. What are the action and reaction forces that are at work when a rocket travels through the vacuum of space?

Rocket pushes exhaust backward; exhaust pushes rocket forward.



13. Newton's 1st Law states that objects do not change
their velocity,

unless acted upon by a net force



14. True or false there is no net force acting on the Earth because the Earth's orbit around the sun is steady and unchanging. Earth is turning, so velocity is changing, so there is a net force

15. True or false As long as your car's speedometer reads a constant 60mph, you can be confident that there is no net force acting on your car. Car could be turning

Suppose a ball is thrown straight up into the sky, **in the absence of air (ignore air resistance)**.

16. During the ball's flight, when is the net force on the ball zero?
a. just after being thrown b. at the highest point
c. just before landing d. both a and c
e. never

17. During the ball's flight, when is the ball's velocity zero?
a. just after being thrown b. at the highest point
c. just before landing d. both a and c
e. never

18. During the ball's flight, when is the ball's acceleration zero?
a. just after being thrown b. at the highest point
c. just before landing d. both a and c
e. never

19. During the ball's flight, when is the ball's kinetic energy zero?
a. just after being thrown b. at the highest point
c. just before landing d. both a and c
e. never

20. During the ball's flight, when is the ball's potential energy zero?
a. just after being thrown b. at the highest point
c. just before landing d. both a and c
e. never



21. A 2kg ball is sitting motionless on the ground.

- a. What is the force of gravity that is acting on the ball?
b. What net force is acting on this ball? 0N
c. Besides gravity, what else is exerting a force on the ball?

$F = ma = 2\text{kg} (10\text{m/s}^2) = 20\text{N}$

20N ↑ ground pushes up $F_{net} = 0\text{N}$
20N ↓ gravity pulls down

22. Explain why it is hard to accelerate when you're standing on very slippery ice.

In order to accelerate forward, you need push the ground backward (but you can't if it's slippery)

23. Suppose you're floating around in space, and there is zero gravity. You have two seemingly identical boxes, but one has more mass than the other.

a. Describe a test you could do to find out which box has the most mass.

Push them both away from you as hard as you can.

b. Explain how you would analyze the results of your test.

The one that is harder to push (and moves slower) has more mass.

24. a. If you were to travel to the moon, what about you would change, your mass or your weight?

b. Explain why one would change and the other would not.

- Mass is your amount of "stuff". You don't gain or lose stuff. Weight is the force of gravity. Less gravity on moon.

25. When the mass of an object is kept constant, how does the acceleration of the object relate to the net force applied to the object?

A) Acceleration doesn't depend on net force at all.

B) Acceleration is directly proportional to net force.

C) Acceleration is inversely proportional to net force.

26) When the force applied to an object is kept constant, how does the acceleration the object relate to a change in the object's mass?

A) Acceleration doesn't depend on mass at all.

B) Acceleration is directly proportional to mass.

C) Acceleration is inversely proportional to mass.

27. Circle the answer that correctly completes the following sentence. When you jump out of a plane, before you reach terminal velocity...

a. your weight equals air resistance.

b. your weight is greater than air resistance.

c. air resistance is greater than your weight.

c. air resistance is equal to your mass.

28. When you are falling at terminal velocity, what is happening to your...

a. KE - *staying the same*

b. PE - *decreasing*

c. Total energy - *decreasing*

29. Why is your total energy changing when you are falling at terminal velocity?

Friction (Air resistance) is "stealing" your energy.

Matching: (Each answer is used exactly once.)

Answers: ~~a. inertia~~ ~~b. acceleration~~ ~~c. scalar~~ ~~d. Force~~ e. terminal velocity
~~f. friction~~ ~~g. vector~~ ~~h. weight~~

30. a Resistance to change in motion
 31. c Having a magnitude but not a direction
 32. b A measure of how fast velocity is changing
 33. d A push or a pull

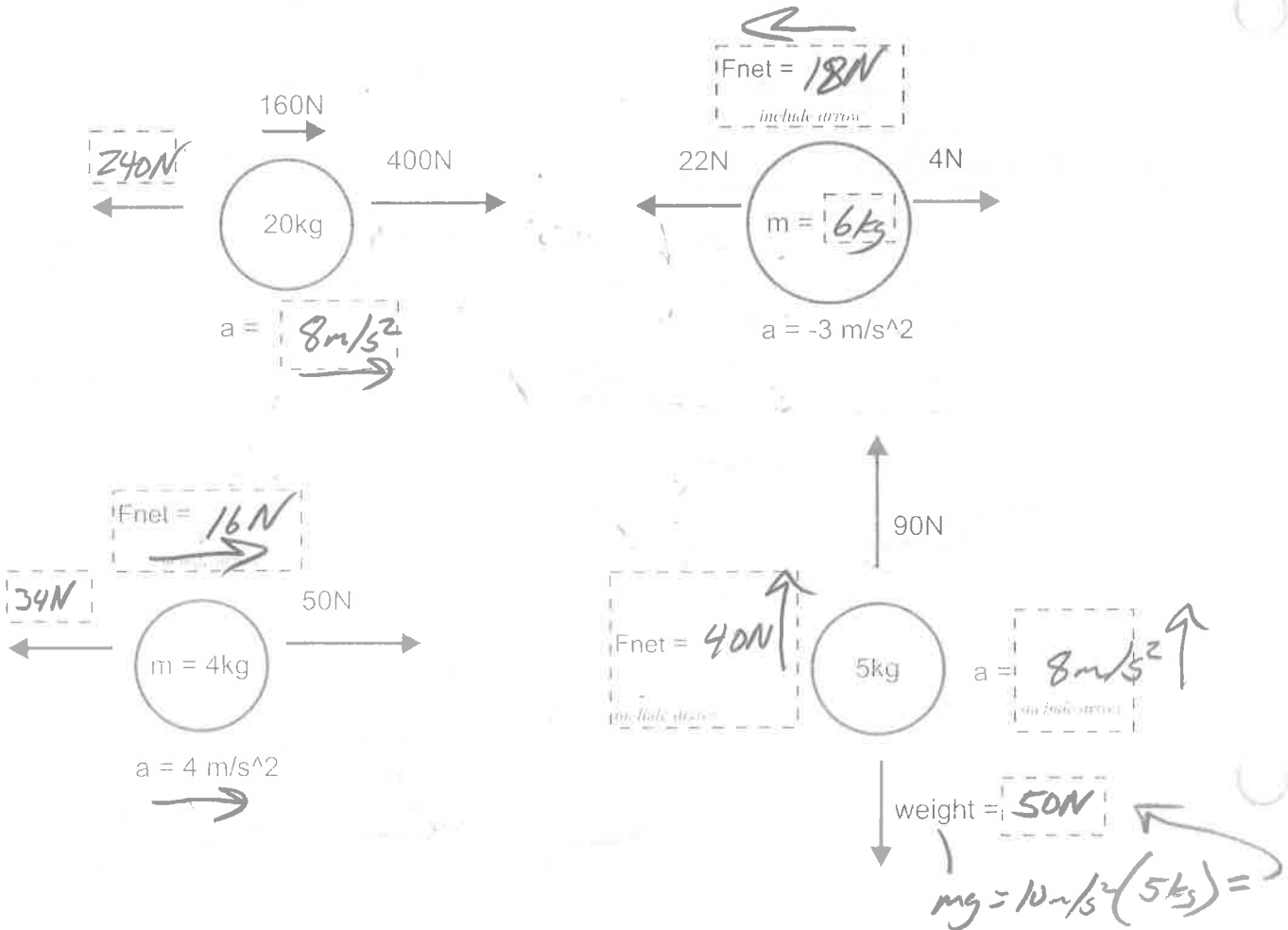
34. f Caused by microscopic bumps in the surfaces of objects
 35. e When weight equals air resistance
 36. h The force of gravity
 37. g Having both a magnitude and a direction

Matching: (Answers are used more than once!)

Choices: Newton kg s m/s^2 m/s N•m j m

38. torque N•m 43. mass kg 48. acceleration m/s^2
 39. air resistance N 44. time s 49. velocity m/s
 40. force N 45. work j 50. distance m
 41. speed m/s 46. weight N
 42. friction N 47. energy j

51. Fill in the dotted boxes on the below. Be sure to label with **correct units!**



52. A net force of 0N (zero net force) is acting on a person. With regard to the person's motion, what are the two fundamentally different possibilities for what that person might be doing?

Possibility 1. *Remaining motionless*

Possibility 2. *Moving in a straight line at a constant speed*

53. What is the mass of an object that has a weight of 10 N on the Earth?

$$W = mg \text{ or } F = ma \quad m = \frac{W}{g} \text{ or } \frac{F}{a} = \frac{10\text{N}}{10\text{m/s}^2} = 1\text{kg}$$

54. The first table, below, is a timeline detailing a parachuter's descent from an airplane. The second table is an incomplete analysis of mass, forces, and acceleration relating to the parachuter's fall. Use the timeline and your knowledge of physics to **complete the second table**. Pay close attention to the times in the second table. Most of them do not coincide with the times in the first table, but you can still use the first table to complete the analysis for those times. Before you go too far, it would be prudent to first identify the times in the second table at which the parachuter has reached terminal velocity.

Time	Event
0s	Parachuter steps out of plane
14s	Parachuter reaches a first terminal velocity of 50m/s
24s	Parachuter pulls chute cord. Chute deploys.
29s	Parachuter reaches a second terminal velocity of 4m/s
375	Parachuter lands

****Please include arrows to show direction.****

Time	Parachuter Mass	Parachuter Weight (plus direction)	Air Resistance (plus direction)	F _{net} (plus direction)	Acceleration (plus direction)	Speed
0s	50kg	500N ↓	0N	500N ↓	10m/s ² ↓	0m/s
5s	50kg	500N ↓	300N Upward	200N ↓	4m/s ² ↓	20 m/s
18s	50kg	500N ↓	500N ↑	0N	0m/s ²	50m/s
25s	50kg	500N ↓	1250N Upward	750N ↑	15m/s ² ↑	40m/s
220s	50kg	500N ↓	500N ↑	0N	0m/s ²	4m/s

55. You take a video of your friend riding down the street on a skateboard. You are using an ordinary camera or smart phone, so the frame rate is 30fps. You open up the video and click frame-by-frame as your friend rolls past a car. The length of the car is 5m, and your friend rolls past the car in 18 frames.

- a. How long did it take for your friend to roll past the car?
 b. How fast was your friend going?

$$v = \frac{d}{t} = \frac{5\text{m}}{0.6\text{s}} = 8.33\text{m/s}$$

$$\frac{18\text{frames}}{30\text{frames/sec}} = 0.6\text{s}$$

Part IV:

1. Suppose you want to loosen a nut that is firmly screwed onto a bolt. You have a 0.2m long wrench, and you can generate a maximum force of 200N, but that's not good enough. In order to loosen the nut using your particular wrench, you would need to apply a 600N force at the end of the wrench.

a. How much torque is required to loosen the nut? $\tau = fr = 600N(0.2m) = 120N \cdot m$

- b. You can remove the nut if you extend your wrench. How long (minimum) does your wrench need to be so that your 200N of force is sufficient for loosening the nut?

$$\tau = fr \rightarrow r = \frac{\tau}{f} = \frac{120N \cdot m}{200N} = 0.6m$$

2. You can think of torque as a "twisting force," but that wouldn't be exactly right. Why not?

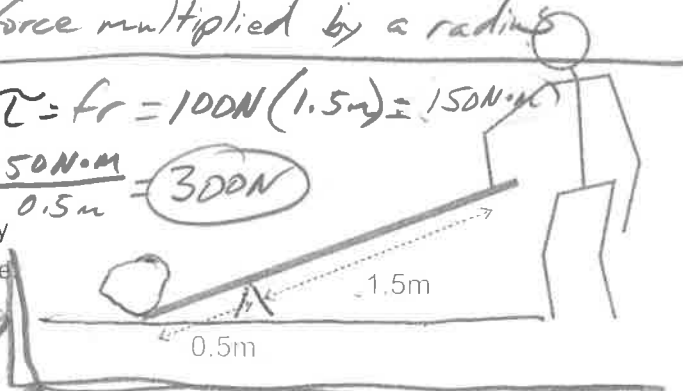
Torque isn't just a force. It's a force multiplied by a radius

3. Wanda is lifting a rock by using a lever (see diagram).

Wanda pushes down on the lever with 100N of force, how much force is applied to the rock?

$$\tau = fr = 100N(1.5m) = 150N \cdot m$$

$$f = \frac{\tau}{r} = \frac{150N \cdot m}{0.5m} = 300N$$



4. Explain why traction (friction with the ground) ultimately limits how fast a car, a bicycle, or a runner can accelerate.

5. Suppose your rubber band car has wheels that are spinning out.

- a. Explain how this could be fixed by changing only the diameter of the drive wheels.

Increase wheel diameter

- b. Explain why this method works.

Force and radius are inversely proportional. Increasing wheel radius decreases wheel force

6. Pam is sitting on the middle of a very light, very strong board. The board is so light and strong that you can ignore its mass. Pam weighs 400N. The board is supported on one end by a low wall and on the other end by Wanda's cousin, Bob.



- a. Bob wants to lift Pam a vertical distance of 0.5m. How much work must Bob do to accomplish this?

$$W = fd = 400N(0.5m) = 200J$$

- b. If Bob grabs the end of the board, he has to lift the board 1m in order to lift Pam 0.5m. How much force will Bob need to apply?

$$W = fd \Rightarrow f = \frac{W}{d} = \frac{200J}{1m} = 200N$$

- c. How much torque is Pam generating?

$$\tau = fr = 400N(2m) = 800N \cdot m$$

- d. The torque created by Pam sitting on the board generates a downward force at the end of the board. What is that force?

$$f = \frac{\tau}{r} = \frac{800N \cdot m}{4m} = 200N$$

Part V: Lab Activities

1. Analyze the deceleration of a sliding object.
 - a. Goal: determine the force of friction acting on the object.
 - b. Directions:
 - i. Get a timer.
 - ii. Find a nice section of hallway.
 - iii. Slide the object a distance of at least 5m.
 1. Time how long it takes the object to come to a stop.
 2. Measure the distance that the object slid, in floor tiles.
 - iv. Do this three times and average your data
 - v. Record your data in a data table

	Distance(tiles) <i>Count them</i>	Time (s) <i>Timer</i>
Trial 1		
Trial 2		
Trial 3		

- vi. Use the balance in the classroom to measure the mass of your object.
- vii. Perform the necessary calculations to fill out the following information:
 1. Object mass (g) *Use electronic balance*
 2. Object mass (kg) $kg = \text{grams} \div 1000$
 3. Average Slide distance (floor tiles) *→ Add trials & divide by 3*
 4. Average Slide distance (m) *tiles x 0.305*
 5. Average Slide time (s) *→ Add trials & divide by 3*
 6. Object initial KE – just after you released it (appropriate units) $KE = \frac{1}{2}mv^2$
 7. Object initial velocity – just after you released it (appropriate units) $v = at$
 8. Object average velocity (m/s) $v = \frac{d}{t}$
 9. Object acceleration (appropriate units) $a = \frac{2d}{t^2}$ *← make it negative, since stick is slowing*
 10. Force of friction (appropriate units) $f = ma$

~~2. Measure the energy input of a rubber band car~~

- ~~a. Goal: determine the car's energy input~~
- ~~b. Directions:

 - ~~i. Get one of the example cars. Assume that the car is wound until all of the string is wrapped around the axle.~~
 - ~~ii. Use a spring scale to determine rubber band forces.~~
 - ~~iii. Perform the necessary calculations to fill out the following information:

 - ~~1. Work distance (m)~~
 - ~~2. Average Force (appropriate units)~~
 - ~~3. Energy Input (appropriate units)~~~~~~