Name _____

The use of a calculator and a cheat-sheet (as instructed) is allowed.
Put your cellphone, laptop, and Apple Watch in your backpack and place the backpack at the front of the hall.
Anyone found in possession of these items during the exam will be expelled from the exam.
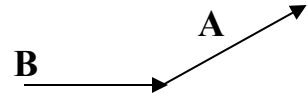
> Part A (40 points) : 10 *Conceptual questions*.
> SHOW REASONING CLEARLY.
> Correct answer w/o **clear** reasoning = ZERO credit!
> Each question is worth 4 points.

1. Vectors **A** and **B** are represented by the arrows shown.
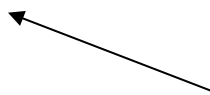   The arrow that likely represents **B** - **A** is:

   a)

   b)

   c)

   d)

   Show reasoning by making an appropriate drawing.

2. The graph shows position as a function of time
   for two trains running on parallel tracks.
   Which statement(s) below is(are) true?
   a) Somewhere on the graph, both trains
      have the same acceleration vector.
   b) Both trains have the same velocity at some
      time before t_B
   c) Both trains speed up all the time.
   d) At time t_B, both trains have the same velocity.

   REASONING:

1
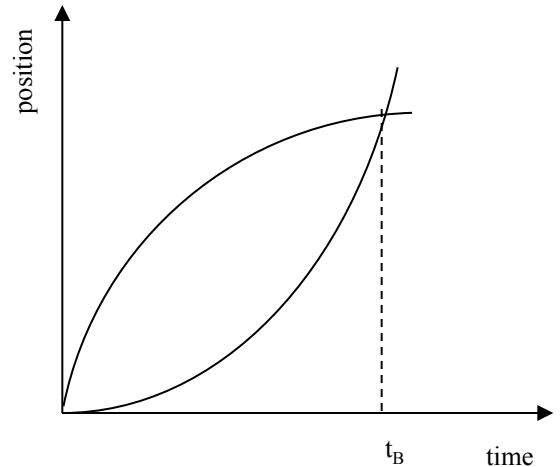
3. A person standing at the edge of a cliff throws one ball straight up and another straight down at the same initial speed. *Taking air resistance into account*, which ball hits the ground below the cliff with greater speed? (Assume the cliff is not so high that terminal velocity sets in!)

a) the ball initially thrown upward   b) the ball initially thrown downward

c) neither – they both hit at the same speed   d) can't say; need more information
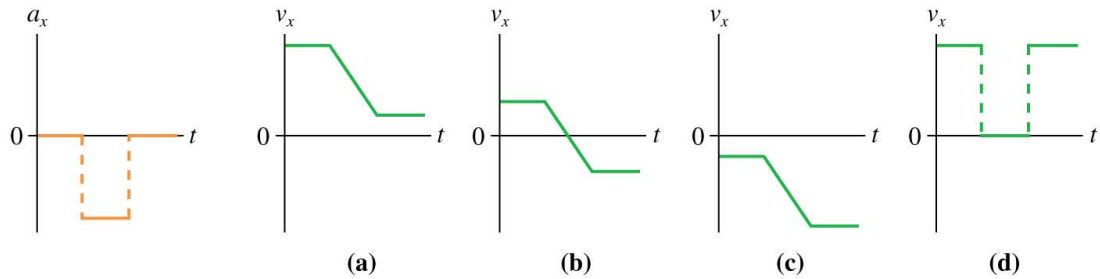
REASONING:

4. A moving particle has the following displacement-time graph. Which of the choices a, b, c, or d below may best represent the corresponding approximate velocity-time and acceleration-time graphs?

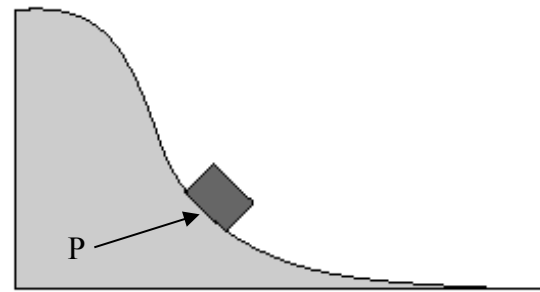(a)   (b)   (c)   (d)

REASONING:

2
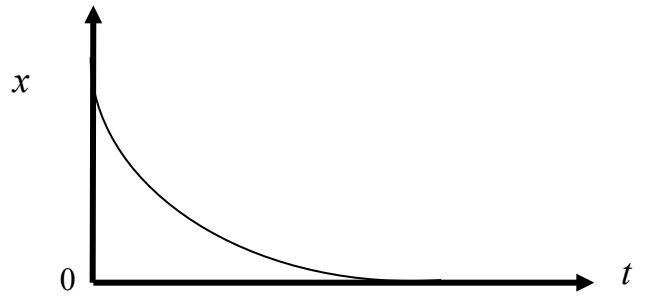
5. Which velocity-versus-time graph or graphs go with the acceleration-versus-time graph on the left? The particle is initially moving to the right (i.e., in the positive x-direction).

(a)   (b)   (c)   (d)

REASONING:

6. A block slides down the frictionless track as shown. The picture shows the block passing from the region of steeper slope to the region of gentler slope. What happens to its speed and acceleration in the direction of motion as it passes the point P shown in the picture?
a) Both decrease.
b) Speed decreases, but acceleration increases.
c) Both remain constant.
d) Speed increases, but acceleration decreases.
e) Both increase.
REASONING:

7. Two teletubbies, Tinky-Winky and Po, who are of very unequal mass, are standing at the edge of a cliff. A homicidal parent sneaks up behind them and pushes them both simultaneously off the cliff. The heavier Tinky-Winky barely drops off the cliff, while the lighter Po rockets off the cliff with a velocity (only horizontal; no vertical component) of 5 m/s.
Neglecting air resistance, which of the following statements is true?
a) They both hit the ground at the same time, and die a miserable death.
b) Tinky-Winky hits the ground first, and dies a miserable death.
c) Po hits the ground first, and dies a miserable death.
d) Can't say - need more information. But they both die. Miserably.
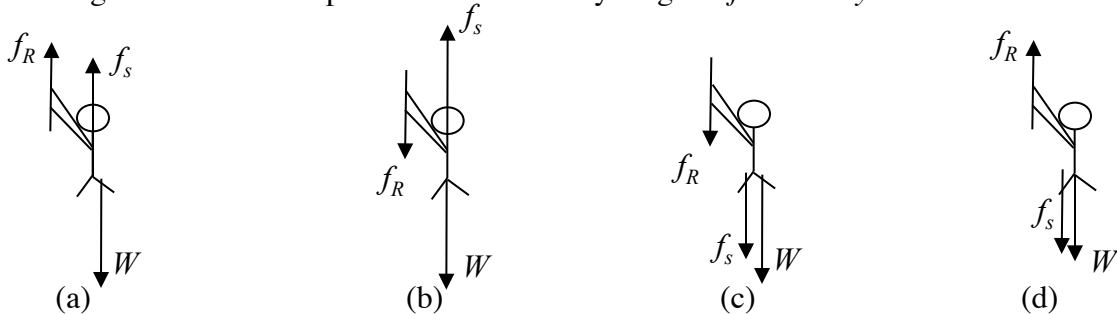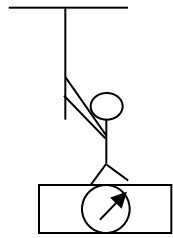REASONING:

3

8. A ladybug sits at the outer edge of a turntable that is rotating in the manner shown but is continually <u>slowing</u> down. What is the direction of the *total acceleration* of the bug, at the instant shown?
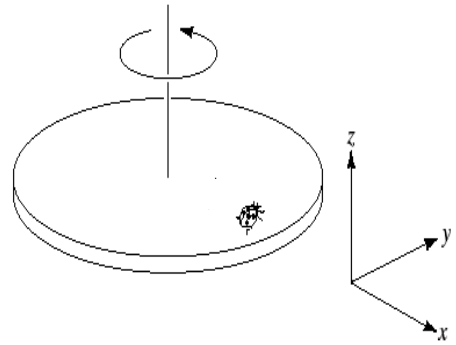
a) +z   b) -z

c) pointing in a direction between y and -x

d) pointing in a direction between -y and -x

e) pointing in a direction between -y and x

REASONING:

9. A boy stands on a scale and pulls on a rope tied to the ceiling as shown. The boy has weight W, and pulls down on the rope with a force of magnitude f_R. The magnitude of the force exerted by the boy on the scale is f_S. Which figure below best represents the free-body diagram *for the boy*?
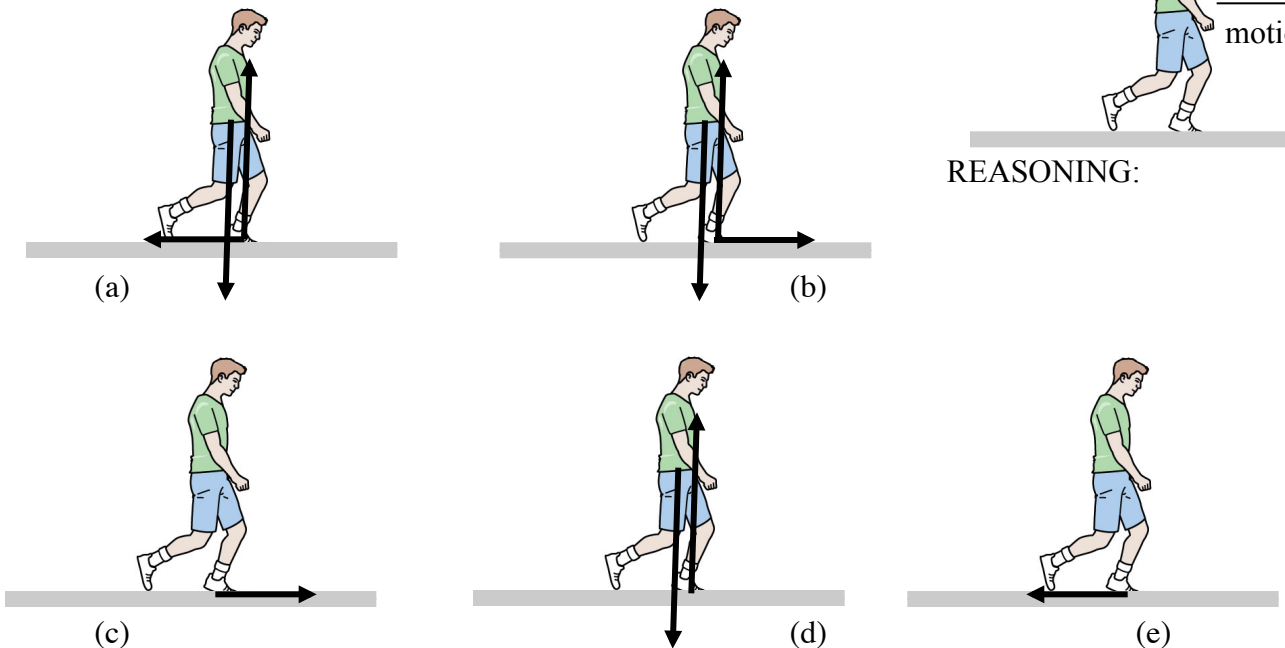
(a)   (b)   (c)   (d)

REASONING:

10. Consider a person walking on level ground, without slipping, in the direction shown. Which below represents the correct free body diagram for the person?

motion

REASONING:

(a)   (b)

(c)   (d)   (e)

4
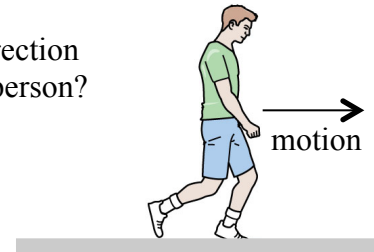
Part B, Questions 11 – 13 (3 points) : 3 *Extra Reading Questions*.
Pick the correct answer. No need to show reasoning!
Each question is worth 1 point.

11. The *primary* reason you must never shake a small baby with even moderate force ("moderate force" meaning such a force would have no damaging effect on an adult) because
    a) you may damage the baby's rib cage even if you're holding it lightly.
    b) the baby's neck muscles are weak and unable to stabilize the relatively large head as it rapidly jerks back and forth owing to its inertia.
    c) the baby's brain does not completely fill the cranial cavity, which leads to brain damage owing to the brain freely sloshing back and forth owing to the brain's inertia.

11. The *principal* reason that humans can throw better than other, far stronger and more athletic, primates is because
    a) humans have bigger brains allowing them to figure out the physics behind throwing projectiles.
    b) humans evolved weaker bites which then caused them to throw better.
    c) humans have better socialization skills allowing them to discuss amongst themselves and arrive at a suitable solution.
    d) human shoulder sockets face out to the side, whereas they face forwards for other primates.

12. The Hyperloop refers to a proposed monorail transport system between San Francisco and Los Angeles which envisages a passenger-carrying "pod" with metal skis, that runs within a tube which has been evacuated to one-thousandth of atmospheric pressure. A linear induction motor similar to those used in modern roller coasters accelerates the pod up to speed. The *primary* purpose of a fan placed in front of the pod is
    a) to keep the passengers cool
    b) to re-direct the built-up air in front of the pod onto the rail, reducing kinetic friction with the rail.
    c) to suck away the built-up air in front of the pod and re-direct it to the surrounding air, so that the pod does not explode due to the pressure outside the pod being dangerously low.

14. An antelope accelerates at 2.0 m/s² along a straight path. It passes two marks that are 30 m apart at times $t = 4.0$ s and $t = 5.0$ s. What was the antelope's velocity at $t = 0$ s?   (8 pts)
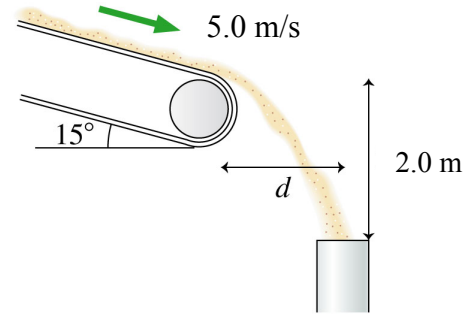   SHOW WORK CLEARLY:

6

15. Gravel is carried at 5 m/s by a conveyor belt that is tilted at 15^0. The gravel enters a pipe
2.0 m below the end of the conveyor belt, as shown. What is the horizontal distance d
between the conveyor belt and the pipe?   (10 pts)
SHOW WORK CLEARLY:

5.0 m/s

$15°$

d

2.0 m

16. Starting from rest, a cheetah rapidly accelerated and closes in on a fleeing gazelle. The cheetah can accelerate with constant acceleration for 2 s before reaching top speed. It then continues at this top speed until it eventually catches the gazelle after running a total distance of 160 m in 8 s. What is the cheetah's speed as it catches up with the gazelle? (12pts)
SHOW WORK CLEARLY:

17. A catapult launches a rocket at an angle of 53.0^0 above the horizontal with an initial speed of 100 m/s. The rocket engine immediately starts to burn and for 3.00 sec the rocket *moves along its initial line of motion* with an acceleration of 30.0 m/s^2. Then its engine fails, and the rocket proceeds to move in free fall. Find   (15 pts)
    a) the maximum altitude reached by the rocket
    b) its total time of flight
    c) its horizontal range

9

18. A disk which is 8.0 cm in diameter has a small dot painted on its edge. The disk is initially at rest, then accelerates at 600 rad/s^2 for ½ s, after which it coasts at a steady angular velocity for another ½ s.   (12 pts)
   a) What is the speed in m/s of the dot at t = 1.0 s?
   b) Through how many revolutions has the disk turned?