## Fundamental Mechanics: Class Exam 3

11 November 2022

Name: $\qquad$ Total:

## Instructions

- There are 8 questions on 6 pages.
- Show your reasoning and calculations and always explain your answers.

Physical constants and useful formulae

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g=9.81 \mathrm{~m} / \mathrm{s}^{2}
$$

## Question 1

A crate is dragged along a rough horizontal surface by a rope and moves 4.00 m during a certain period of observation. The rope exerts a 100 N force along the illustrated direction.

a) Determine the work done by the rope during the period of observation.
b) During the period of observation, the cart moves with constant speed. Determine the work done the kinetic friction force.

## Question 2

A crate is suspended by a rope and is lowered vertically. While this happens, which of the following (choose one) is true about the work done by the rope, $W$ ?
i) $W>0$ if the crate speeds up and $W<0$ if it slows down.
ii) $W<0$ if the crate speeds up and $W>0$ if it slows down.

iii) $W>0$ regardless of the speed.
iv) $W<0$ regardless of the speed.

## Question 3

Two boxes are released from rest at the same height on identical frictionless surfaces. The mass of box B is four times that of box A. They collide with and compress identical springs. Which of the following (choose one) is true regarding the maximum compression of each spring ( $\Delta x_{A}$ for that with box $\mathrm{A}, \Delta x_{B}$ for that with box B$)$ ?

i) $\Delta x_{B}=4 \Delta x_{A}$.
ii) $\Delta x_{B}=2 \Delta x_{A}$.
iii) $\Delta x_{B}=\Delta x_{A}$.
iv) $\Delta x_{B}=\frac{1}{2} \Delta x_{A}$.
v) $\Delta x_{B}=\frac{1}{4} \Delta x_{A}$.

## Question 4

A 2.00 kg block can move along a vertical cylinder. The block is held at rest against a spring with spring constant $400 \mathrm{~N} / \mathrm{m}$, compressing it by 0.250 m . At this instant, the base of the block is 0.250 m beneath the top of the cylinder. The block is released and when the base reaches the top of the cylinder, it leaves the spring, moving with speed $2.00 \mathrm{~m} / \mathrm{s}$. While it moves up the cylinder a constant kinetic friction force acts on the block. For purposes of gravitational potential energy, let $y=0$ correspond to the situation where the bottom of the block would lie on the base of the cylinder.

a) Determine the energy of the system at the moment that the block is released.
b) Determine the work done by the friction force and use this to determine the magnitude of the friction force.

## Question 5

A particle with the illustrated total mechanical energy moves subject to the illustrated potential. Indicate all locations where the speed is a maximum and the force on the particle is zero. Explain your answer.


## Question 6

A particle can move horizontally along the $x$ axis. The potential energy of the particle is $U=a x^{2}+b x^{4}$ where $a=-6.0 \mathrm{~J} / \mathrm{m}^{2}$ and $b=3.0 \mathrm{~J} / \mathrm{m}^{4}$. Determine the force on the particle, including direction, at $x=2.0 \mathrm{~m}$.

## Question 7

Two blocks are initially at rest on a frictionless track as illustrated. Block B, with mass 2.0 kg is released from rest at an unknown height above the horizontal surface. It descends and collides with block A, with mass 4.0 kg . They stick together and subsequently move with speed $2.5 \mathrm{~m} / \mathrm{s}$.

a) Determine the speed of block B immediately before the collision.
b) Determine the height above the horizontal surface from which block $B$ was released.

## Question 8

Two ice skaters, Alice with mass 60 kg and Bob with mass 90 kg , slide toward each other on a sheet of ice. Alice moves right with speed $10 \mathrm{~m} / \mathrm{s}$ and Bob moves left with speed $5.0 \mathrm{~m} / \mathrm{s}$. They collide and Bob subsequently moves right with speed $1.5 \mathrm{~m} / \mathrm{s}$. Ignore friction and air resistance.
a) Determine Alice's speed after the collision.
b) Explain whether the total mechanical energy defined as $E=K+U_{\text {grav }}$ is conserved in this collision.

