Instructions: Write your NAME and your SECTION (01 = 8:30/Eskildsen, 03 = 3:00/Goussiou) on the front of the blue exam booklet. The exam is closed book, and you may only use your pens/pencils and calculator (no stored equations or programs, no graphing).

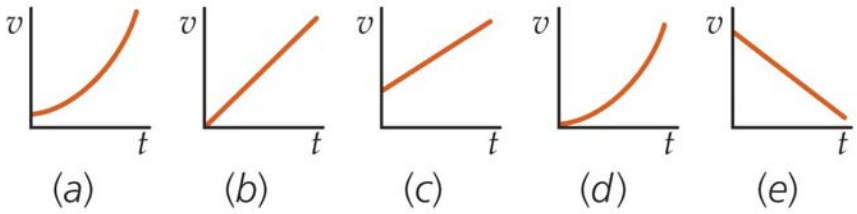
For problems II-V you must write the complete solution in your blue book. No credit (full or partial) will be given for an answer with no supporting work. Draw a diagram when possible, circle or box your final answers, and cross out parts which you do not want us to consider.

I. Multiple choice questions

MC1. When a object falls through air, there is a drag force $F_{air} = CAv^2$, where A is the surface area, v is the velocity, and C is a constant. What are the dimensions of C in SI units?

A) N
B) m^2/s^2
C) m^4/s^2
D) kg m/s^2
E) kg/m^3

MC2. Assume that a Trabant (car manufactured in East Germany before the country collapsed) accelerates uniformly from 25 mph (40 km/h) at $t = 0$ to 35 mph (56 km/h) at $t = 120$ s. Which graph below best describes the motion of the car?



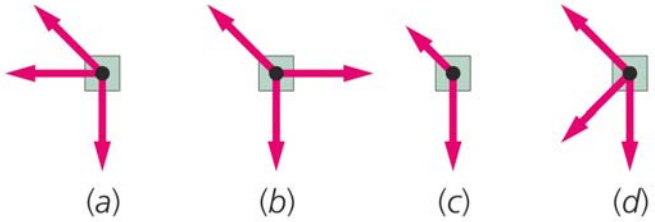
MC3. A cargo plane is flying horizontally at an altitude of 9 km with a speed of 900 km/h when a large crate falls out of the rear loading ramp. What is the total distance (horizontal and vertical) between the crate and the plane when the crate hits the ground, assuming that the plane continues to fly with constant velocity? Ignore air resistance.

A) 3.3 km
B) 9 km
C) 10.7 km
D) 12.3 km
E) 14.0 km

MC4. A person with weight w is in an upward-moving elevator when the cable suddenly breaks. What is the apparent weight of the person after the elevator starts to fall?

A) w
B) greater than w
C) less than w, but not zero
D) zero
E) $w/(9.81\ \text{m/s}^2)$

MC5. Which of the free-body diagrams below represents a block sliding down a frictionless inclined surface?

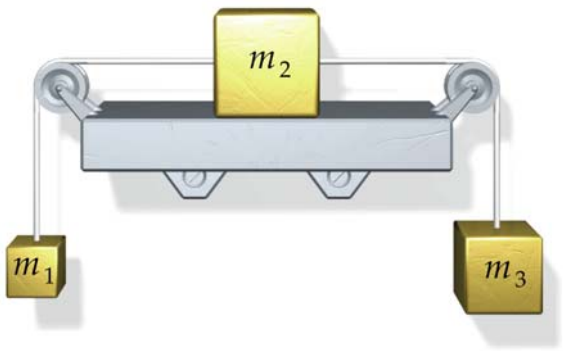


Problems

II. A cannon is elevated at an angle of 65°. It fires a ball with a speed of 250 m/s.

a) What height does the ball reach?
b) How long is the ball in the air?
c) What is the horizontal range of the cannon?

III. A box of mass m_2 = 4.0 kg rests on a frictionless horizontal shelf and is attached by strings to boxes of masses m_1 = 1.5 kg and m_3 = 2.5 kg, which hang freely, as shown in the figure. Both pulleys are frictionless and massless. Strings are taut and non-stretching. The system is initially held at rest. After it is released find:



a) The acceleration of each of the boxes.
b) The tension in each string.

IV. In the figure to the right, a 0.500 kg block is suspended from the center of a 1.2 m long string. The ends of the string are attached to the ceiling at points separated by 1.0 m.

(a)

a) What angle, θ, does the 1.2 m string make with the ceiling?
b) What is the tension in each branch of the 1.2 m string?

(b)

The 0.500 kg block is now removed and two 0.250 kg blocks are attached such that the three string segments have the same length, as shown in the figure to the left. The ends of the string attached to the ceiling are still separated by 1.0 m.

c) What is the tension in each segment of the string?

V. A rocket is fired vertically. While the engine is on the rocket accelerates upwards with $a = 20$ m/s^2. After 20 s the engine is shut off and the rocket then continues rising (while in free-fall). The rocket eventually stops rising and then falls back to the ground.

a) What is the highest point the rocket reaches?
b) What is the total time the rocket is in the air?
c) What is the speed of the rocket just before it hits the ground?