Drake Physics Prize Practice Test (Part II)

STUDENT: **SCHOOL:** **PROCTOR:**

Please, circle your answers among the multiple choices and write down all your solutions in detail. If you need more paper, please, indicate the problem number you are solving, write your name and school name on each page and staple all your papers together.

1. A block of mass m = 2 kg is attached to a spring with spring constant $k = 1.70 \times 10^3$ N/m, and rests on a frictionless, horizontal surface. The block is pushed such that that the spring compresses by a distance x = 6 cm from the equilibrium position, and released from rest.
(i) What is the maximum value of the object's acceleration?
(ii) What is the speed of the block when it passes through the equilibrium position?
(iii) What is the speed of the block when it passes through position x = 3 cm relative to equilibrium?
(iv) At what distance from equilibrium is the kinetic energy of the mass equal to its potential energy?

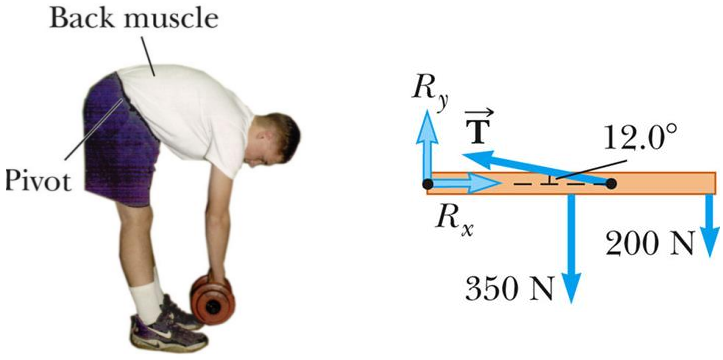
(a) (i) 29.2 m/s^2 (ii) 3.50 m/s (iii) 0.52 m/s (iv) + 0.04 m
(b) (i) 51.0 m/s^2 (ii) 1.75 m/s (iii) 1.52 m/s (iv) ± 0.04 m
(c) (i) 51.0 m/s^2 (ii) 1.75 m/s (iii) 1.22 m/s (iv) ± 0.02 m
(d) (i) 51.0 m/s^2 (ii) 3.50 m/s (iii) 0.52 m/s (iv) + 0.02 m
(e) (i) 29.2 m/s^2 (ii) 3.50 m/s (iii) 1.52 m/s (iv) ± 0.04 m

2. A 10-kg block is launched up a plane inclined at a 15° angle. The initial speed of the block is 5 m/s.
(i) How far up the inclined plane (parallel to the plane's surface) does the block slide if the coefficient of kinetic friction between the block and the surface is μ_k = 0.20?
(ii) Let the coefficient of static friction between the block and the surface be μ_s = 0.35. In part (i), once the block stops, does it start to slide back down or does it remain at rest? Explain your reasoning.
(iii) Calculate the angle of the inclined plane for which the block in part (ii) is on the verge of slipping.

(a) (i) 2.82 m (ii) Yes (iii) 19.3^o
(b) (i) 5.10m (ii) No (iii) 30.0^o
(c) (i) 2.82 m (ii) Yes (iii) 19.3^o
(d) (i) 1.91 m (ii) Yes (iii) 30.0^o
(e) (i) 2.82 m (ii) No (iii) 19.3^o

STUDENT: **SCHOOL:**

3. A person bends forward to lift a 200-N weight, until his spine becomes almost horizontal (figure on the left). The person's spine pivots mainly on the fifth lumbar vertebra, with the main muscle force provided by the erector spinalis muscle in the back. A schematic lever representation of the system is shown on the right. The spine is represented as a horizontal rod pivoted on the left point, at the base of the spine. The weight of the spine and upper body is 350 N, acting in the middle of the rod. The muscle, shown as a vector **T** acting at a point two-thirds up the spine, maintains the position of the back. The angle between the spine and the muscle is 12°, as shown. Calculate the horizontal (R_x) and vertical (R_y) components of the reaction force, **R**, with the correct sign.



(a) R_x = 2646.4 N, R_y = -12.5 N
(b) R_x = -2646.4 N, R_y = -12.5 N
(c) R_x = 12.5 N, R_y = 2646.4 N
(d) R_x = 2646.4 N, R_y = 12.5 N
(e) R_x = -2646.4 N, R_y = 12.5 N

4. An object of mass *m* is released from rest at the top of a building having a height *h*. A wind blowing along the side of the building exerts a constant horizontal force of magnitude *F* on the object as it drops. The air exerts no vertical force. How far from the building will the object hit the ground? Express your result as a function of *h*, *F* and *m*.

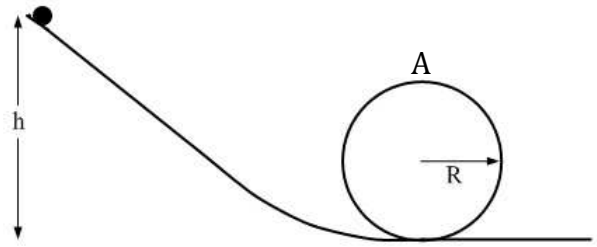
(a) $\frac{F\,h}{2\,m\,g}$
(b) $\frac{F\,h}{m\,g}$
(c) $\frac{2\,F\,g}{m\,h}$
(d) $\frac{gh}{m\,F}$
(e) $\frac{F\,h}{4\,m\,g}$

STUDENT: **SCHOOL:**

5. Two forces, $\mathbf{F_1} = 2\,\mathbf{i} - 5\,\mathbf{j}$ and $\mathbf{F_2} = \mathbf{i} + \mathbf{j}$, are exerted on an object with a mass of 5 kg starting at $t = 0$. t is time, and **i** and **j** are the unit vectors in a rectangular coordinate system. If the object has an initial velocity (at $t = 0$) of 2.5 m/s in the positive x direction, what is the speed of the object after 4 seconds (in m/s)?

(a) $\mathbf{v} = 4.9\,\mathbf{i} - 3.2\,\mathbf{j}$
(b) $\mathbf{v} = 7.0\,\mathbf{i} + 4.0\,\mathbf{j}$
(c) $\mathbf{v} = 8.6\,\mathbf{i} + 1.3\,\mathbf{j}$
(d) $\mathbf{v} = 3.0\,\mathbf{i} - 4.0\,\mathbf{j}$
(e) $\mathbf{v} = 2.5\,\mathbf{i} - 3.2\,\mathbf{j}$

6. A small object of mass $m = 2$ kg, initially at rest, is released from a height $h = 4.5$ m and slides down a frictionless inclined plane until it reaches a vertical circular track. As the object slides without rolling along the interior surface of the circle, it experiences a constant kinetic friction force of 5.0 N. The radius of the circle is $R = 1.2$ m.



(i) What is the normal force on the ball due to the track at point A?

(ii) What is the minimum height from which the ball needs to be released in order to stay on the track at A and continue moving on the circle?

(a) (i) 4.70 N (ii) 5.12 m
(b) (i) 17.6 N (ii) 3.96 m
(c) (i) 4.70 N (ii) 3.96 m
(d) (i) 17.6 N (ii) 4.50 m
(e) (i) 49.0 N (ii) 3.00 m